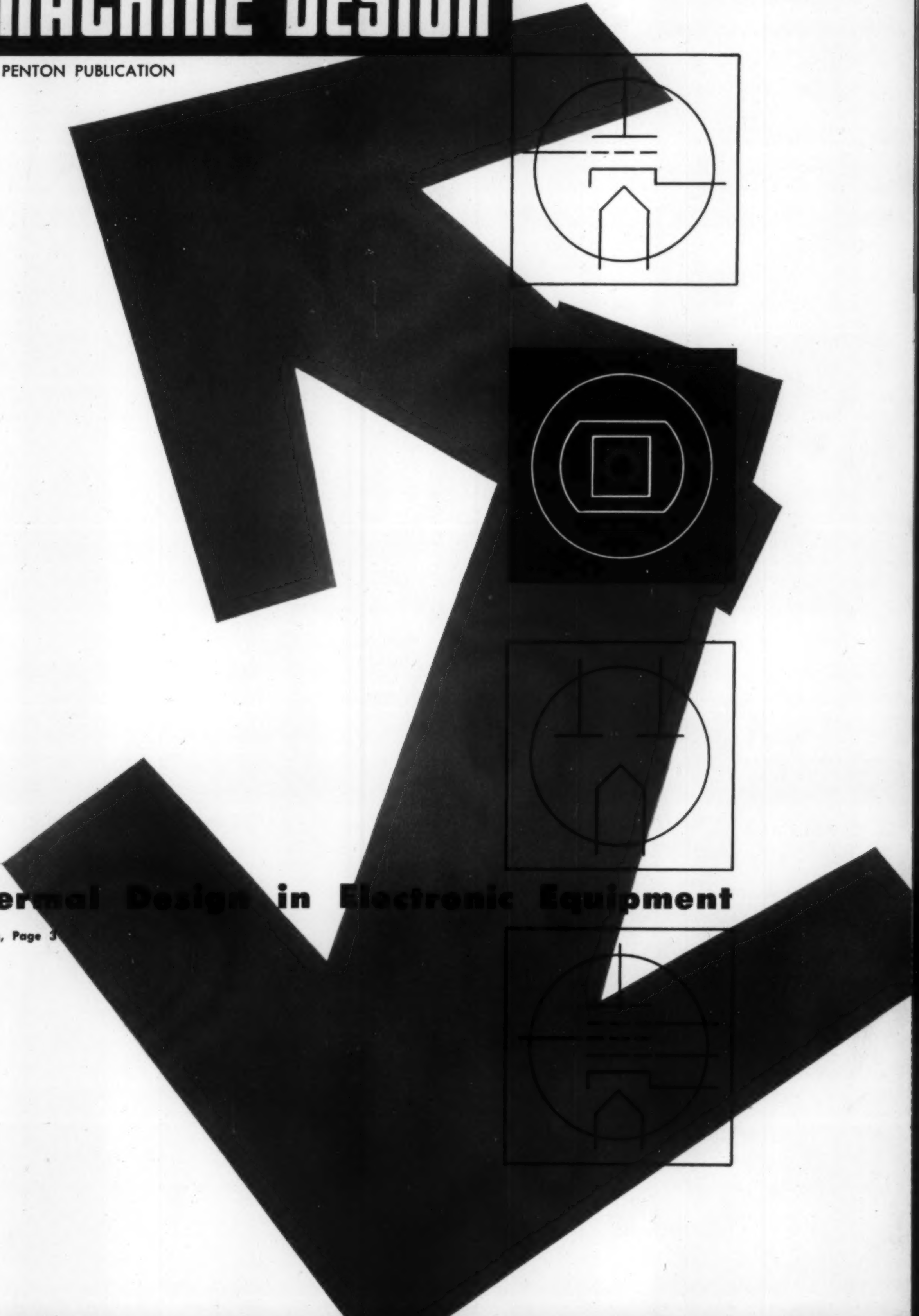
MAY 2, 1957
EVERY OTHER THURSDAY

MACHINE DESIGN

A PENTON PUBLICATION



Thermal Design in Electronic Equipment

Contents, Page 3

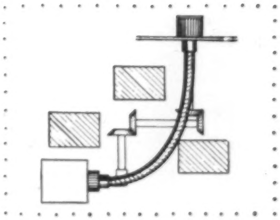
FARNSWORTH

S.S.White
Flexible Shafts
Eliminate
Unnecessary
Parts

One manufacturer used flexible shafts to replace 35 parts in a Hydraulic Power System . . . cut costs by 90%. Four flexible shafts replaced a 35-part remote-control system . . . simplified design . . . made assembly easier . . . eliminated alignment problems . . . improved performance!

This is only one of hundreds of remote control and power drive problems these quality flexible shafts are solving in every industry today. Can S.S. White flexible shafts help improve *your* product? Perhaps make it lighter in weight . . . cut production costs . . . eliminate unnecessary parts?

If you'd like to know more about flexible shafts, the advice of our engineers costs you nothing. Just write to



S. S. White Industrial Division, Dept. 4, 10 East 40th Street, New York 16, N. Y.
Western Office: 1839 West Pico Blvd., Los Angeles 6, Calif.

S.S.White
FIRST NAME
IN FLEXIBLE SHAFTS

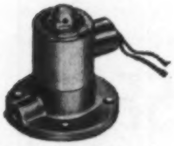
Useful data on how to select and apply flexible shafts! Write for Bulletin 5601.

Circle 401 on page 19

NEW Ross Starline

air control valve series

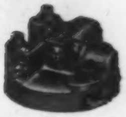
NEW long life


WHITE STAR
SPOOL SOLENOID

GOLD STAR
OIL-IMMERSED SOLENOID

BLUE STAR MV

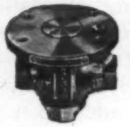
BLUE STAR TD


BLUE STAR WV

NEW match any head to any valve body!

STRAIGHTWAY
NORMALLY
OPEN

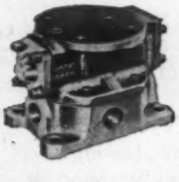
STRAIGHTWAY
NORMALLY
CLOSED



3 WAY
NORMALLY
OPEN

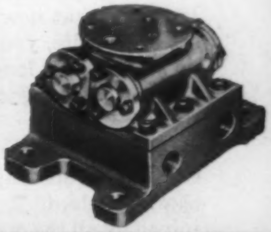
3 WAY
NORMALLY
CLOSED

3 WAY
NORMALLY
OPEN



3 WAY
NORMALLY
CLOSED

4 WAY



Tests indicate a trouble-free life of over 25 million cycles for valves with the spool solenoid pilot section, and *more than 40 million for all other Starline* valves shown.

Heads and bodies are completely and instantly interchangeable. Sizes from ¼" to 1¼". Even *more* Starline models coming later. Write for Starline data file.

A Galaxy of New Air-Control Stars Are Coming Your Way From

Ross OPERATING VALVE COMPANY

109 EAST GOLDEN GATE AVENUE • DETROIT 3, MICHIGAN

Circle 404 on page 19

Another Goodyear First:

V-Belts with the Green Seal

GREEN
SEAL
GREEN SEAL

The Green Seal means Dimensional Stability

stay matched from factory to drive

The Green Seal signifies true dimensional stability. It means that now when you reach for a matched set of V-belts, you can be sure they're matched – no matter how long they've lain on the shelf. And that means longer life and a minimum of down time.

It used to be that only steel-cable V-belts by Goodyear were length stabilized. But now, through the miracle of Triple-Tempering, they've been joined by all the other Goodyear Industrial V-belts.

Triple-Tempering is the exclusive process wherein synthetic cord is carefully brought to the peak of strength and stability by controlled tempering with Tension, Temperature and Time. And this gives you not only *length* stability in storage, but greater shock- and stretch-resistance on the drive.

In addition to 3-T load-carrying members, the Green Seal also brings you "balanced construction." This means each component of the belt is specifically designed to its job to give you cleaner, smoother, longer running which adds up to maximum, trouble-free horsepower hours at minimum cost.

The next time you need V-belts, be sure they're wearing the Green Seal—the mark of a V-belt made with the technical know-how of the world's largest rubber company. They're readily available at your Goodyear Distributor. Or write for details to Goodyear, Industrial Products Division, Lincoln 2, Nebraska, or Akron 16, Ohio.

DIMENSIONALLY STABLE V-BELTS by

GOODYEAR

THE GREATEST NAME IN RUBBER

Green Seal—T. M. The Goodyear Tire & Rubber Company, Akron, Ohio

Circle 405 on page 19

THE PROFESSIONAL JOURNAL
FOR ENGINEERS AND DESIGNERS

MACHINE DESIGN

May 2, 1957
Volume 29—No. 9

EDITORIAL STAFF

COLIN CARMICHAEL, Editor
BENJAMIN L. HUMMEL, Assoc. Managing Editor
ROBERT L. STEDFELD, Assoc. Managing Editor
LEO F. SPECTOR, Associate Editor
ROBERT C. RODGERS, Associate Editor
WILLIAM S. MILLER, Associate Editor
SPENCER R. GRIFFITH, Associate Editor
JOHN B. HOLT, Assistant Editor
FRANK M. BUTRICK JR., Assistant Editor
FRANCIS A. HUSARIK, Assistant Editor
JANE H. SMITH, Assistant Editor
MARIAN L. VLASAK, Editorial Assistant
FRANK H. BURGESS, Art Editor
ROGER W. BOLZ, Contributing Editor

EDITORIAL OFFICES

Penton Building, Cleveland 13, O.

Branch offices: New York, Detroit, Chicago, Pittsburgh, Washington and London

REGULAR DEPARTMENTS

Engineering News Roundup 5
Index 17
Meetings and Expositions 31
Helpful Literature 120
New Parts and Materials 126
Engineering Dept. Equipment.. 148
The Engineer's Library 154
Noteworthy Patents 156

POSTAGE-FREE CARDS . . . 19
for further product information and extra copies of editorial articles

MACHINE DESIGN is sent at no cost to management, design and engineering personnel whose work involves design engineering of machines, appliances, electrical and mechanical equipment, in U. S. and Canadian companies employing 20 or more people. Copies are sent on the basis of one for each group of four or five readers. Consulting and industrial engineering firms, research institutions and U. S. government installations performing design engineering of products are also eligible.

Subscriptions in United States, possessions, and Canada for home-addressed copies and copies not qualified under above rules: One year, $10. Single copies $1.00. Other countries: One year, $25. Published every other Thursday and copyrighted 1957 by Penton Publishing Co., Penton Bldg., Cleveland 13, Ohio.

Accepted as Controlled Circulation publication at Cleveland, Ohio.

When requesting changes of address, etc., please allow four to six weeks for processing.

The Human Side .... *Editorial* 73

Standards for Performance Quality .... *By M. W. Papp* 74
An analysis of the role of formal performance specifications in maintaining quality of manufactured products at a high level.

Scanning the Field for Ideas 79
Electron-tube "contactors" in motor-control circuits — cast-in-place steel segments in aluminum parts — adjustable division of liquid flow.

Right of Invention .... *By Albert Woodruff Gray* 81
How the courts have solved the problem of assigning patent rights when there is more than one inventor to be considered.

Thermal Design in Electronic Equipment .... *By Thomas C. Reeves* 84
A practical design guide on solution of "heat" problems in assemblies employing electronic and electrical components — thermal design objectives, procedures for minimizing heat generated by components, techniques for isolating and removing heat efficiently from equipment.

Hydraulic Cylinders .... *By H. L. Stewart and J. M. Moritz* 94
A summary of ten methods for synchronizing cylinder motions.

Design in Action 98
Ease of accessibility and operation featured in design of television camera with local video control — movable cutting head employed in contour sawing machine of articulated construction.

Small Extension Springs .... *By P. F. Recca and Fred W. Smith* 102
A simplified approach to design and specification of springs for operation under fatigue-load conditions where space is limited.

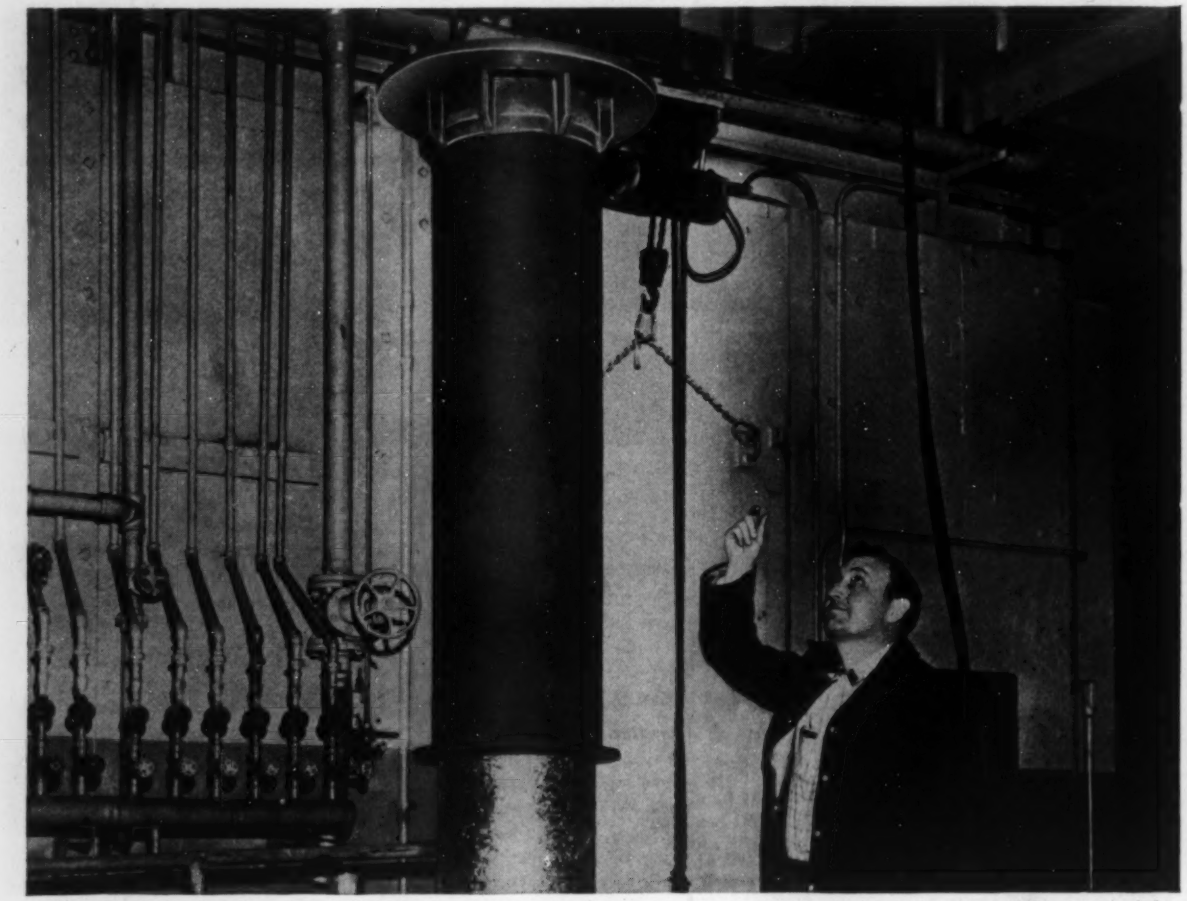
What Are Engineers Made Of? .... *By Edwin C. Nevis* 109
The Personal Side of Engineering — The first article of two dealing with the "anatomy" of the engineer's personality and attitudes.

Bolt-Hole Circles .... *By Donald E. Sweet* 111
Data Sheet — Table of co-ordinate constants simplifies hole location.

Shell Castings .... *By H. G. Sieggreen* 112

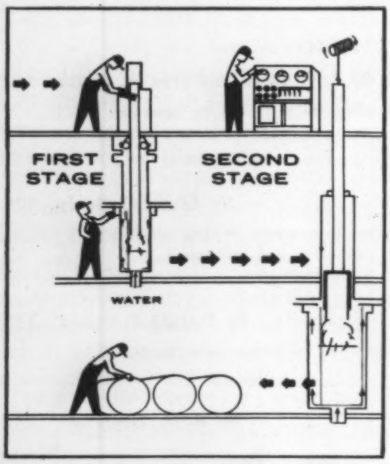
Bearings .... *By E. G. Jackson and E. R. Booser* 114

Tips and Techniques: Estimating weight of bar stock, 108; drawing gear teeth, 110; experimental parts 110.



STRIPPING titanium ingot from crucible fabricated from Anaconda large-diameter seamless copper tube. During melting, the crucible is water cooled.

How Copper helps make superior Titanium Ingots



SPONGE TITANIUM pressed into electrodes is melted in the first-stage arc furnace, forming ingots. Several such ingots are welded together and used as an electrode in the second melting. Double melting gives homogeneous, uniform ingots. A vacuum in the crucible assures low hydrogen content.

Titanium and titanium-alloy ingots that are homogeneous and have low carbon and hydrogen content are difficult to produce. Mallory-Sharon Titanium Corp. of Niles, Ohio, however, originated the double-melting process, "Method S," for production, which does the job.

A major factor in the successful production of ingots of sound structure is the use of water-cooled copper crucibles. Mallory-Sharon found that copper met the requirements for a satisfactory crucible material, particularly because of its high thermal conductivity.

Mallory-Sharon fabricates some of its crucibles more easily and quickly, using large-diameter Anaconda seamless copper tube for the body of the crucible. Various sizes are used for the crucibles—for example 20″ I.D. x ½″ wall thickness; and 15¼″ I.D. x ⅜″ wall thickness. These big Anaconda tubes are now playing a key role in producing the ever-growing tonnage of the new structural metal so vital in the production of America's jet planes.

The American Brass Company produces the widest range of seamless tubes available to industry. At one end are tubes in copper and copper alloys up to 26″ I.D. At the other are the capillary tubes as small as .032″ O.D. and wall thickness of .005″—for instrument control, activating lines, and other precision purposes.

Whatever your tubing problem, see your American Brass Company representative. Or write: The American Brass Company, Waterbury 20, Conn.

5764

ANACONDA®

TUBES AND SHELLS in Copper, Everdur®, Cupro Nickel, Brass

Made by The American Brass Company

Circle 406 on page 19

Engineering News Roundup

Sensitive Radios To Monitor Satellite's Faint Voice

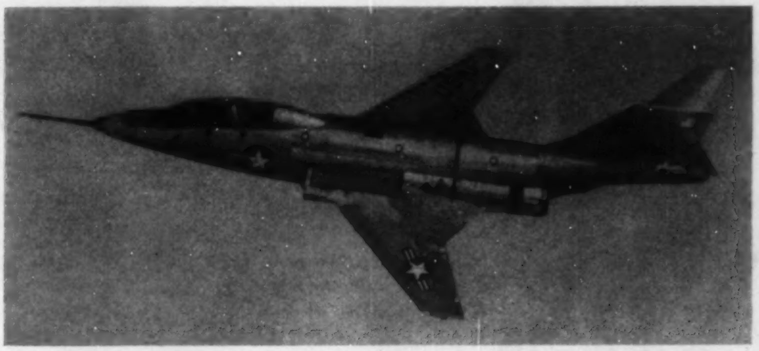
Split-Second Timing Will Enable Course Plots

NEW YORK, N. Y.—Radio equipment so sensitive it can "hear" invisible stars will be used for tracking the first man-made earth satellite to be launched some time during the International Geophysical Year, July 31, 1957 to Dec. 31, 1958. The ultrasensitive radio, called Minitrack, was designed and built originally by the Naval Research Laboratory. Currently, the Minitrack system and eleven other receivers to help in the tracking operation are under construction at Bendix Aviation Corp. They will be strategically placed up and down the American continents to tune in radio signals from the satellite.

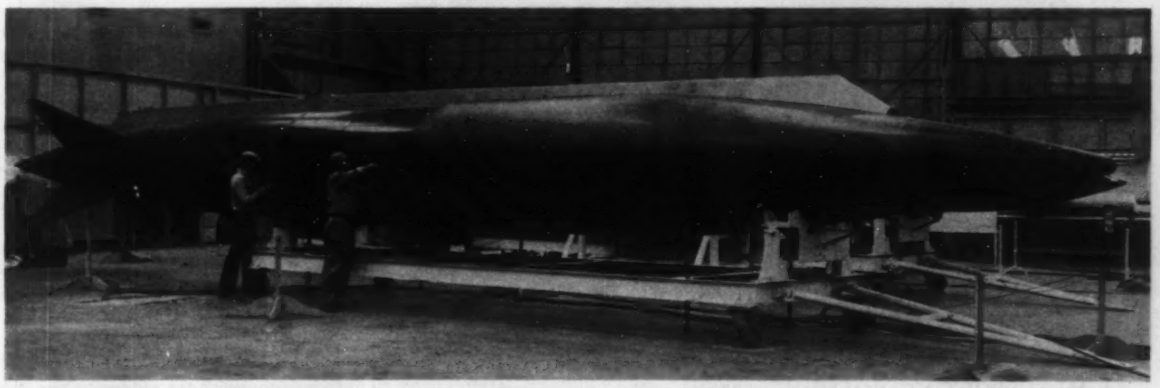
The satellite's 13-oz transmitter will broadcast on a frequency of 108 mc with a power of from 10 to 50 milliwatts. This is only one-millionth as strong as the signal of a standard radio broadcasting station. Equipment sensitive enough to receive this signal can detect the presence of stars that emit no visible energy.

One function of Minitrack will be to determine speed and direction of the satellite so that its orbit can be plotted. The tracking will be accomplished by the chain of 12 Minitrack receivers. Minitrack sites will be interconnected to form a continuous "fix" on the vehicle.

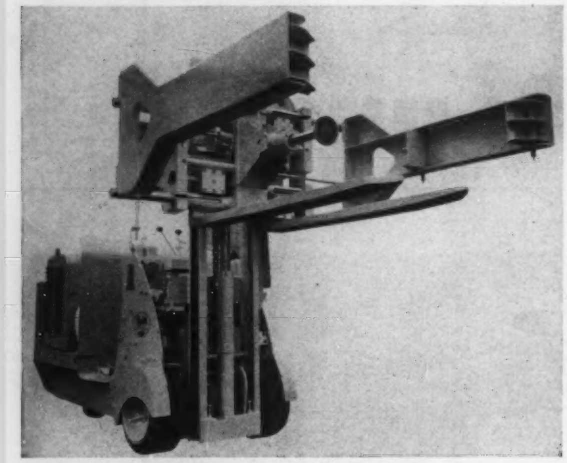
A complete Minitrack system will occupy six racks, each about the size of a filing cabinet. Each system, housed in an air-conditioned mobile trailer, will receive



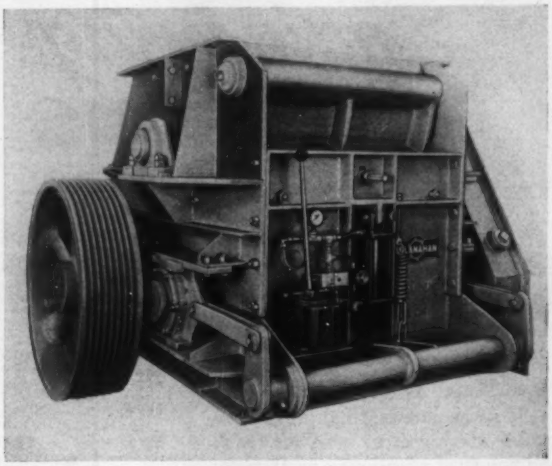
VOODOO FOR TWO is this newest Air Force interceptor which has recently completed its first test flight. Designated F-101B, this is the third of a series by McDonnell Aircraft Corp., all called Voodoo. Similar in outer appearance to its predecessors, the F-101B Voodoo is an interceptor with all-weather, long-range capabilities. It has exceptional climb performance to very high altitudes. It is the first Voodoo to carry a crew of two.



DETACHABLE UNDERSLUNG POD for the B-58 Hustler receives finishing touches prior to attachment. The Air Force recently disclosed that the B-58 was designed specifically to carry such capsules. It is now undergoing flight tests at Ft. Worth with "pod" attached. Built by Convair, the "pod" enables the faster-than-sound delta-winged aircraft to perform a great variety of missions.



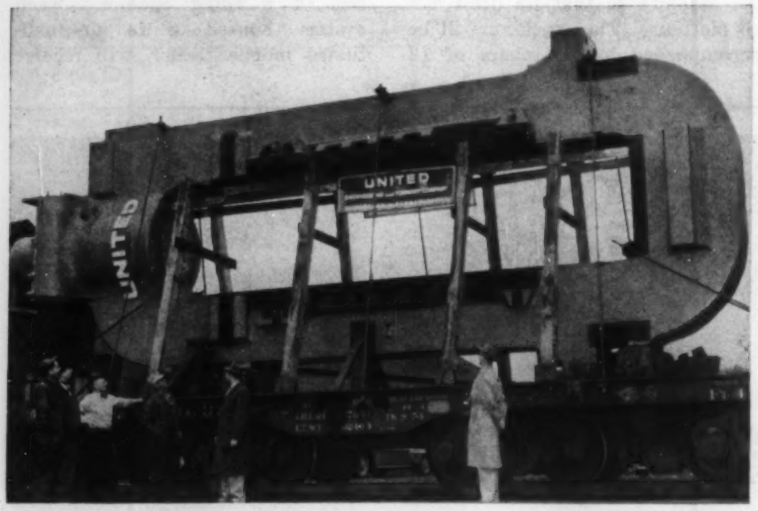
STRONG ARMS and a hydraulic ram are special features of this lift truck with which one man, singlehanded, removes and replaces the work roll chocks in a steel rolling mill. Arms and ram are new attachments for Skylift model by Automatic Transportation Co. It handles chocks from 3200 to 4000 lb. Forks lift the chocks from the roll while arms grip the chocks and the ram pushes on the roll. Then rolls are removed for regrinding. Formerly, chock removal required an overhead crane and a floor crew.



THREE ROLLS IN TWO STAGES make this new coal crusher by McLanahan and Stone Corp. the first of its type. Crusher breaks run-of-mine chunks into uniform pieces as small as $\frac{1}{2}$-in.; as large as 6 in. Primary feed is crushed by an 18-in. roll against a curved plate. Toothed crusher roll is said to accept large volume without splintering the coal into fines. Two more 18-in. rolls perform secondary reduction. Hydraulic system positions the secondary rolls. Their opening can be changed with coal in process.

---

signals picked up from eight antennas separated as much as 500 ft. Minute differences in time required for the satellite's signal to reach each of several antennas will be used to determine the position of the 20-in. sphere 200 to 1500 miles above the earth.



TOPS IN SUPPORTING ROLLS, this 203-ton mill housing is the largest of its type ever cast. The housing and a 198-ton companion unit will support rolls for a 168-in. four-high hot reversing mill at Kaiser's new aluminum production center in Ravenswood, W. Va. Cast by United Engineering and Foundry Co., the housing required a special flat car.

Radar Restitutor Restores Photo Accuracy

SYOSSET, N.Y.—Distorted photographs of radar displays are now reproduced correctly after distortion errors have been computed automatically. The corrections are made by a device known as the Radar Restitutor.

The chief distortion in original radar air photographs is due to the fact that radar records the slant distance from an aircraft to a ground object. For mapping purposes, the ground distance from the radar to an object is required.

The Radar Restitutor, designed

Front Cover

Temperatures in improperly designed electronic equipment can get high enough to fry an egg. Artist George Farnsworth depicts the problem on the front cover; author Thomas C. Reeves gives answers in his article beginning on Page 84.

. . . Fluid Power news

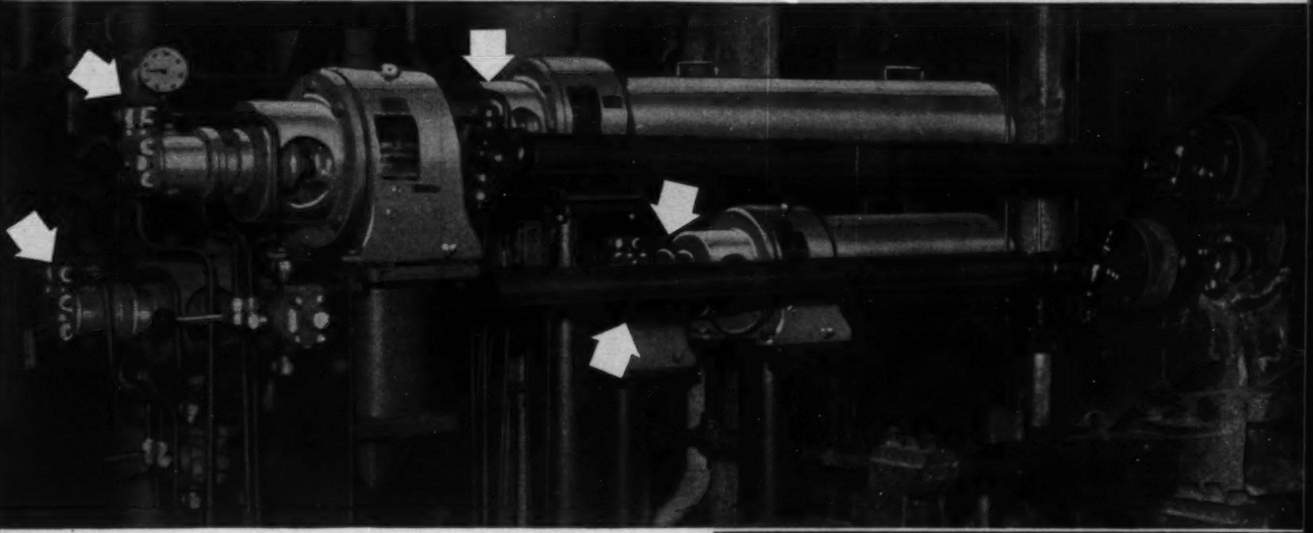
REPORT:
No. 12,100
MOTOR
TROUBLES
SOLVED

From Oilgear Application-Engineering Files

HOW OILGEAR "ANY-SPEED" DRIVES ON PAPER MACHINE SOLVED MOTOR TROUBLES

CUSTOMER: *A Large Paper Company (Name withheld by request)*

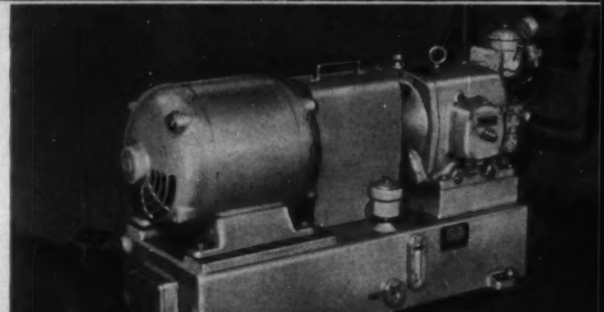
DATA: For modernizing a paper machine installed in 1913, rebuilt in 1927. Five drives required for distributor rolls (1 rectifier roll, 2 head rectifier rolls, 2 slice box rectifier rolls) in head box on wet, or fourdrinier end, to spread wet paper pulp "blanket" on wire mesh for removal of water. Due to standard mill practice of daily equipment washdown with high pressure hoses, plus high humidity during operation, use of 5 electric, variable-speed drives would have resulted in excessive maintenance costs. Rotational reversal was desirable on the two slice box rectifier rolls. Must have smooth, steady, continuous slow-speed operation at full rated load. Roll synchronization within 10% allowable. Must be compact, easy to install, and maintain.



SOLUTION: Five "Oilgeareducers"—heavy-duty, constant torque, type "H" hydraulic motors integral with Falk Steel Reducers. As accurate roll synchronization was *not* required, motors were driven in parallel from a single Oilgear "DP" variable displacement pump. This pump has an automatic power-conserving control that reduces power input as load requirements diminish. Independent speed controls were installed for each drive. Two 4-way valves provide for instant, cushioned reversal required for two rolls. A completely sealed, compact, "Any-Speed" Fluid Power drive system . . . impervious to washdowns, automatically protected against overload, with full rated torque at any speed . . . to match any requirement. System is pressure and flood-lubricated automatically with the oil in the system. Over a year of continuous service—no maintenance required to date. Performance has proved superior to requested specifications and has made possible some improvements in paper structure.

For practical solutions to your linear or rotary drive problems, call the factory-trained, Oilgear application-engineer in your vicinity. Or write, stating your specific requirements directly to . . .

THE OILGEAR COMPANY
Application-Engineered Fluid Power Systems
1568 WEST PIERCE STREET • MILWAUKEE 4, WISCONSIN

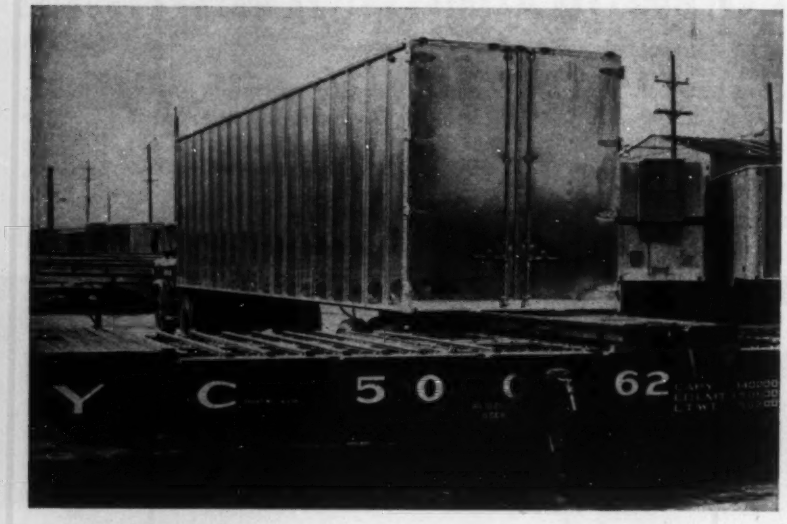


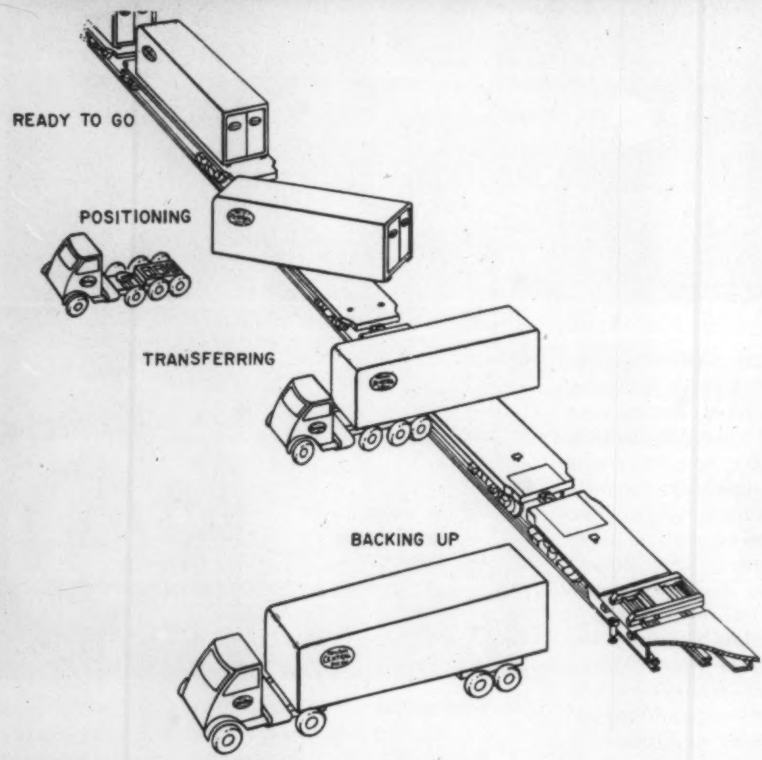
Oilgear "DP" variable displacement pump with automatic power-conserving control, 10-hp electric motor, and reservoir shown mounted in basement below the paper machine away from danger of contamination.

This large producer of glassine and greaseproof papers, has also Oilgear-equipped the winder drive in their converting plant glue machine; the center winder drive on a super-calender stack; the unwind and rewind drives on another super-calender; plus many other mill applications.

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

and built by the Electronics Div. of Fairchild Controls Corp., computes these and other errors which cause the distortions in radar photography. The device then produces new photographs on which all ground objects are accurately located according to corrected co-





FOUR-MINUTE TRANSFER of highway semi-trailer to flatcar was demonstrated recently by the New York Central Railroad and Fruehauf Trailer Co. The new "Flexi-Van Service" will be placed in operation throughout the system this summer. A specially-developed hydraulic lift and turntable on the flatcar pivots the trailer into position. Ordinary flat cars may be adapted for this service. The entire operation can be done by one man.

Topics

Greatest invention since the wheel (round), perhaps, is a newly patented square wheel. The inventor claims that a vehicle with square wheels will ride smoothly and have good traction over soft or rough terrain. Axles move up and down in slots. While one wheel has a flat side down the one adjacent to it is resting on a point.

• • •

Blimp had a big day recently when it broke endurance and distance records for that type of aircraft. The Navy ZPG-2 bettered the previous endurance time of 200 hr, 12 minutes of nonrefueled flight and, later in the same day, exceeded the 6980-mile record set by the Graf Zeppelin in 1929.

• • •

Mail-order nuclear knowledge is available with the addition of a course in elements of nuclear energy to the curriculum of International Correspondence Schools. Students will receive instruction in basic mathematics, physics and chemistry, to be followed by study in the principles of radioactivity and nuclear energy.

• • •

Less noise from jet planes is foreseen. Boeing Airplane Co., which has spent $5 million to develop a noise suppressor for its 707 jet liners, claims that the commercial jet plane of 1958 or 1959 will be no noisier than today's piston-engine aircraft.

• • •

Nameplate is the key to product recognition, according to a recent survey by Lippincott and Margulies. Customers were shown 50 nationally advertised appliances, with the nameplates covered up, and asked to name the manufacturer. Less than one-third could identify any of them.

• • •

Engineering golf clubs to accurately place the proper point of impact in each different head was tried in designing a new set of Spalding irons. It seems that a separate calculation for the height of each club, based on the angle of its face and the diameter of the ball, results in clubs that give a player uniform "feel," maximum power and control. Trigonometry was employed as the means to attain the objective of lowering a golfer's score. Careless addition also helps.

Circle 407 on page 19→

POROUS BRONZE BEARINGS

SELF-LUBRICATING BRONZE BEARINGS

BRONZE SINTERINGS

BRONZE POWDERED METAL BEARINGS

OIL-RETAINING BRONZE BEARINGS

SINTERED METAL BRONZE BEARINGS

OIL-IMPREGNATED BRONZE BEARINGS

CONFUSED?

If you are more concerned with performance than synonyms, simply specify the finest sintered BRONZE

COMPO® BEARINGS

BY

BOUND BROOK

Pioneer in

POWDER METALLURGY BEARINGS + PARTS

BRONZE OIL-LESS BEARINGS

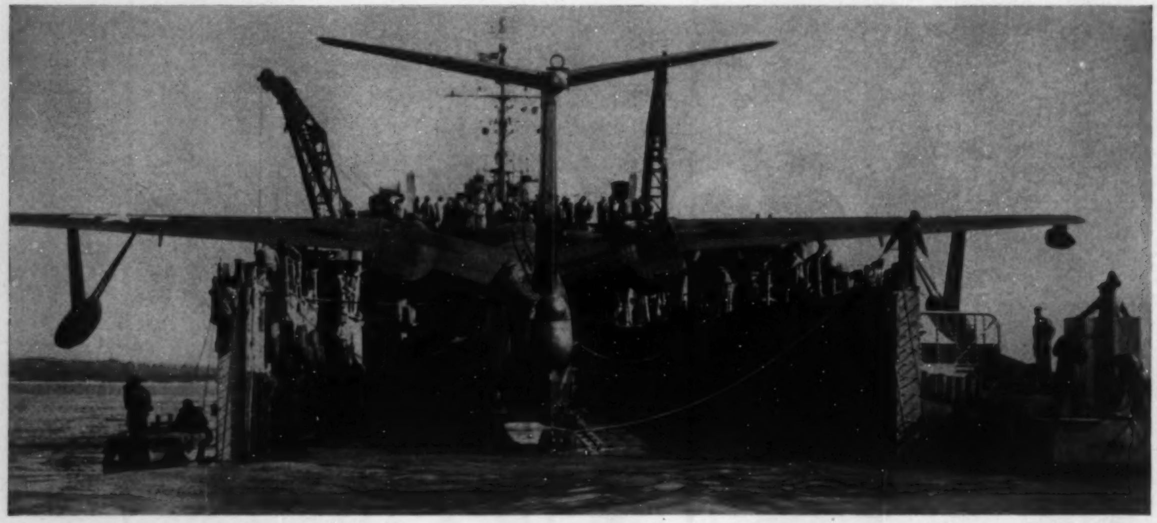
OIL-FILLED BRONZE BEARINGS

POWDER METALLURGY BRONZE BEARINGS

METAL POWDER BRONZE BEARINGS

BOUND BROOK OIL-LESS BEARING CO., BOUND BROOK, N. J. EST. 1883

FLOATING SEAPLANE DRYDOCK is a mission within the capabilities of a Navy LSD (Landing Ship Dock) as this recent demonstration indicated. An antisubmarine plane, the P5M Martin Marlin, taxied within 150 yds of the ship while the LSD took on seawater ballast to leave only 4 ft of freeboard at the stern (above). With lines passed between ship and plane, the P5M was floated into the ship on beaching gear (below). Pumping out ballast raised both ship and plane. Docking operation took 26 minutes.



Registrations Open For 1957 Design Show, Conference

CLEVELAND, OHIO—Designers who plan to attend the 1957 Design Engineering Show and Conference can expedite registration by making application now for both events, May 20 to 23. There will be a $2 fee for registration for the show, Rapid registration forms should be requested from:

Clapp & Poliak, Inc.,
341 Madison Avenue,
New York 17, N. Y.

For hotel reservations, contact:

Miss Sylvia Peltonen,
Manager, Housing Bureau,
New York Convention & Visitors Bureau,
Pershing Square,
90 East 42nd St.,
New York 17, N. Y.

Registration for the 1957 Design Engineering Conference includes admission to the Show. Fee for ASME members is $5; for nonmembers, $10. Conference registrations should be requested from:

Mr. D. B. MacDougall,
American Society of Mechanical Engineers,
29 West 39th St.,
New York 18, N. Y.

Show visitors are welcome to meet the editors of MACHINE DESIGN at Booth 232 on the first floor of the Coliseum. The MD staff values this opportunity to meet readers in person, to have their comments on MD and to discuss their writing ambitions.

Car Owners Say They Like Bright Trim

Brightwork Must Be Durable

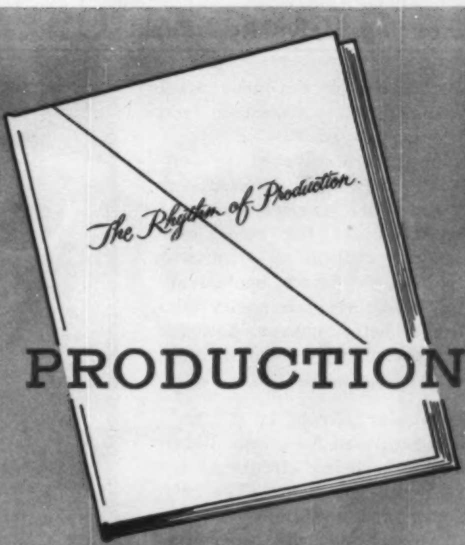
NEW YORK, N.Y.—Results of a recent nation-wide survey of automobile owners warrant these conclusions:

1. A majority of car owners want auto manufacturers to retain or increase the amounts of trim on new models.

2. More than 40 per cent are willing to pay a premium for superior quality trim.

The survey was conducted by the independent research organization of Davee, Koehnlein & Keating of Chicago, and was sponsored by

alone



THE RHYTHM OF PRODUCTION

graphically depicting

AUTOMATIC MASS PRODUCTION TECHNIQUES

This book stands ALONE!

It presents techniques of mass production which are completely changing present concepts of manufacturing.

The principles of Barnes hydraulic controls and actuations as illustrated in this text

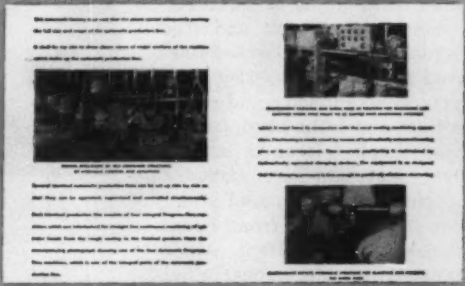
. . . are destined to improve living conditions for every man, woman, and child,

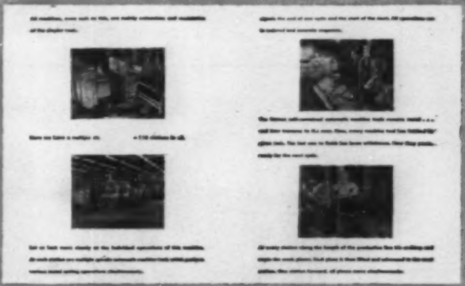
. . . will guide manufacturing techniques to unbelievable productive results,

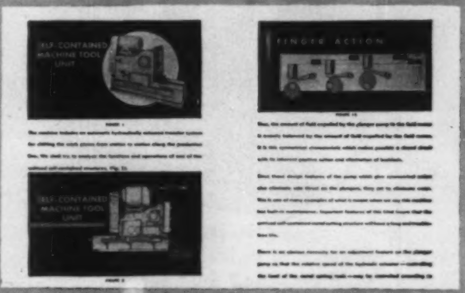
. . . point the road to a better way of life, far in advance of current thinking.

YOUR COPY IS READY! Request it on your company letterhead. This is the first edition. **Act now!**

ALSO AVAILABLE — A full color 16mm. film, "The Rhythm of Production," which vividly illustrates the automatic techniques presented in the book. Write and reserve a date for this movie.






ELF-CONTAINED MACHINE TOOL UNIT
FINGER ACTION
ELF-CONTAINED MACHINE TOOL UNIT

JOHN S. BARNES CORPORATION

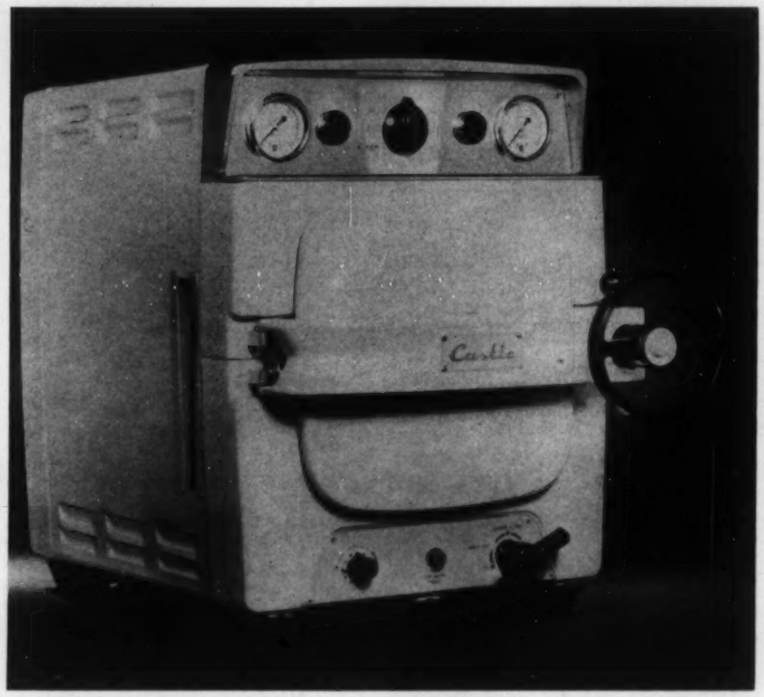
301 SOUTH WATER STREET ROCKFORD, ILLINOIS

Copyright, 1957, John S. Barnes Corporation

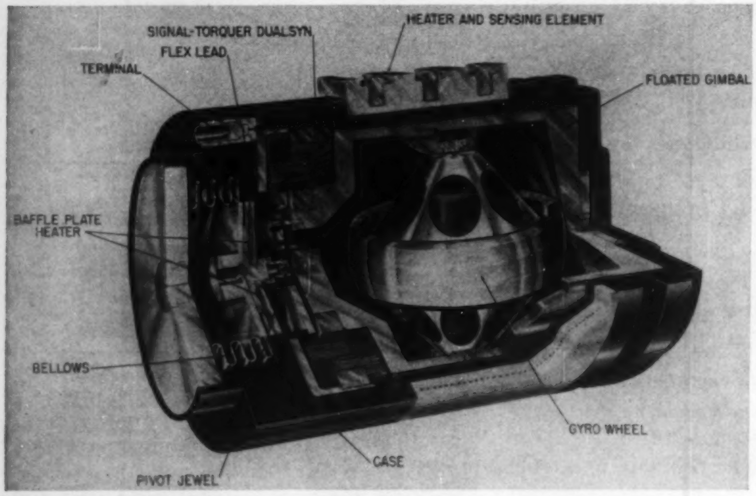
the Committee of Stainless Steel Producers of the American Iron and Steel Institute.

Survey results seemed to confirm manufacturers' contentions that brightwork carries much of the sales appeal for some new models. Opposition to trim was said to stem "almost exclusively from a highly vocal minority who advance esthetic reasons, however real or fancied."

Semitubular Rivets is the subject of a proposed American Standard currently being circulated for criticism and comment. The proposed standard is intended to cover body diameter and head dimensions for three head styles of semitubular rivets—Oval, Truss, and Flat Countersunk. The standard defines the head types and specifies bearing surface, eccentricity and radius of the fillet under the head. Length increments and tolerances as well as rivet materials are included. Free copies of the proposed standard can be obtained from Frank Philippbar, Standards Dept., American Society of Mechanical Engineers, 29 West 39th St., New York 18, N.Y.



COLORFUL STERILIZER will give medical and dental offices a more comfortable and appealing look. Model 999 Autoclave, announced by the Wilmot Castle Co., features single-knob control, recessed instruments, and a large chamber with room for two drawer-size instrument trays. Simplified design eliminates the possibility of steam burns. Smooth appearance is accented by a colored enamel finish.



SIGNAL AND TORQUE-GENERATING GYROSYNS combined in a Dualsyn is the feature of the Miniature Integrating Gyroscope (MIG) recently announced by Aeronautical Div. of Minneapolis-Honeywell Regulator Co. This $\frac{1}{2}$-lb version is intended for short-time or "aided" inertial guidance systems. Dualsyn has four windings of 0.0045-in. wire, two ac for the signal generator and two dc for the torquer. The MIG gyro is 1.75 in. in diameter and 2.5 in. long. It will drift less than 0.5-degree per hr.

High-Current Glow Discharge Gives Science New Tool

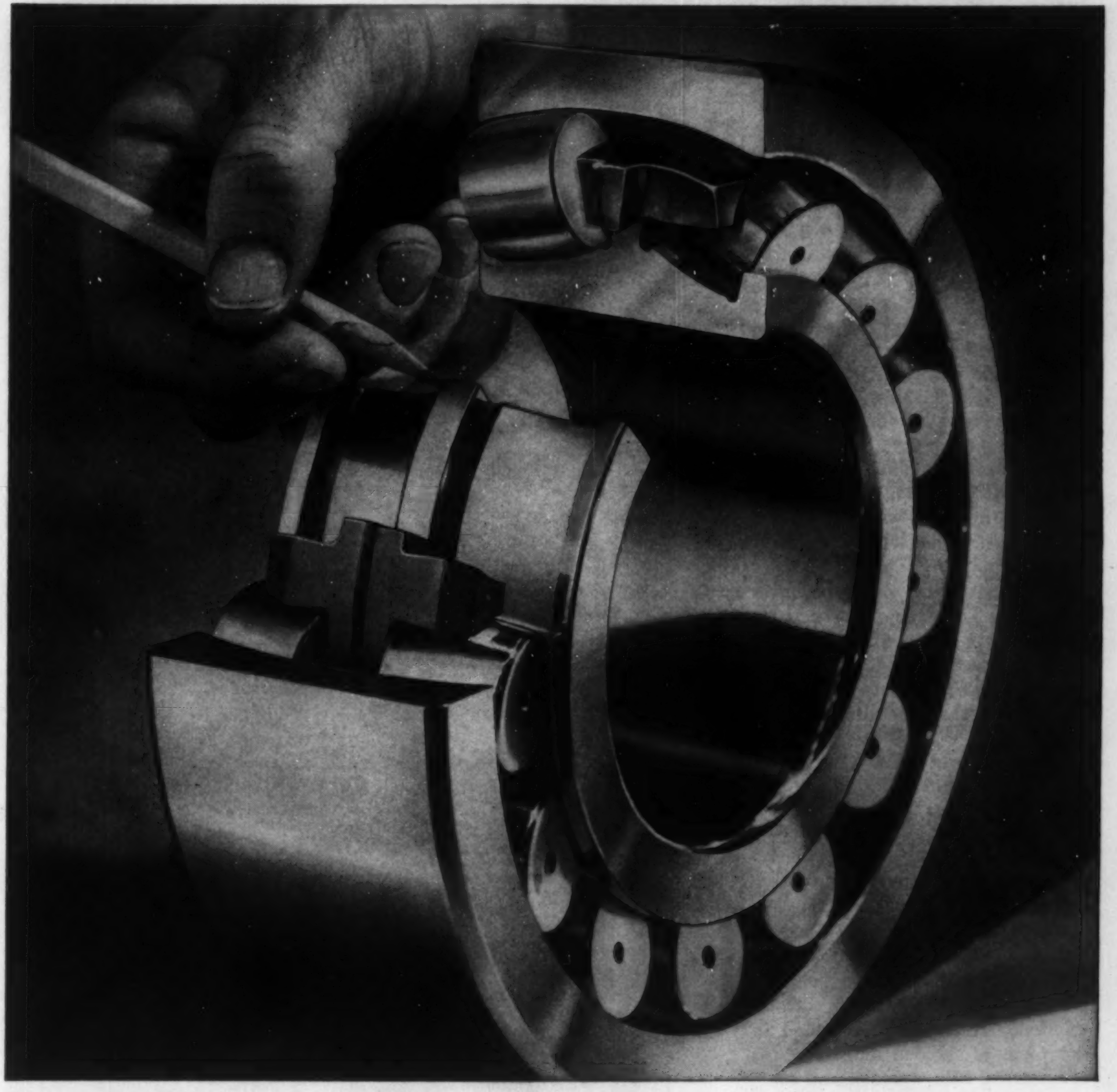
Research Institute To Develop Berghaus Process

WASHINGTON, D.C.—The first successful application of the Berghaus Process for the ionitriding of steel was announced recently in Dusseldorf, Germany. The process, named after Bernard Berghaus, converts electrical energy into thermal energy through high-current glow discharge.

The development of this high-current glow discharge suggests applications of the process in the fields of chemistry and nonferrous metallurgy. Science may now have the means of cracking gases into their atomic components.

In the Berghaus Process, electrical energy is used to accelerate large masses of nitrogen and hydrogen. The impact of the ions on the surface of the electrically iso-

TORRINGTON *SPHERICAL ROLLER* BEARINGS



"This flange guides the rollers to peak performance!"

The center flange on the inner raceway of the TORRINGTON Spherical Roller Bearing positions the rollers to handle thrust loads. This accurate positioning also assures radial stability of the rollers under heavy loads—even at continuous high speeds and under conditions of misalignment.

This superior design feature is only one of many advantages you get when you specify TORRINGTON. For example, you get the service of TORRINGTON'S experienced engineers, who will help you with design and maintenance problems—or design custom bearings for special applications.

For long, low-maintenance service in heavy-duty applications, order TORRINGTON Spherical Roller Bearings. They're available from stock with either straight or tapered bore, for shaft or adapter mounting.

THE TORRINGTON COMPANY
South Bend 21, Ind. • Torrington, Conn.
District offices and distributors in principal cities of United States and Canada

Visit Torrington at the
1957 Design Engineering Show
New York Coliseum May 20 to 23.

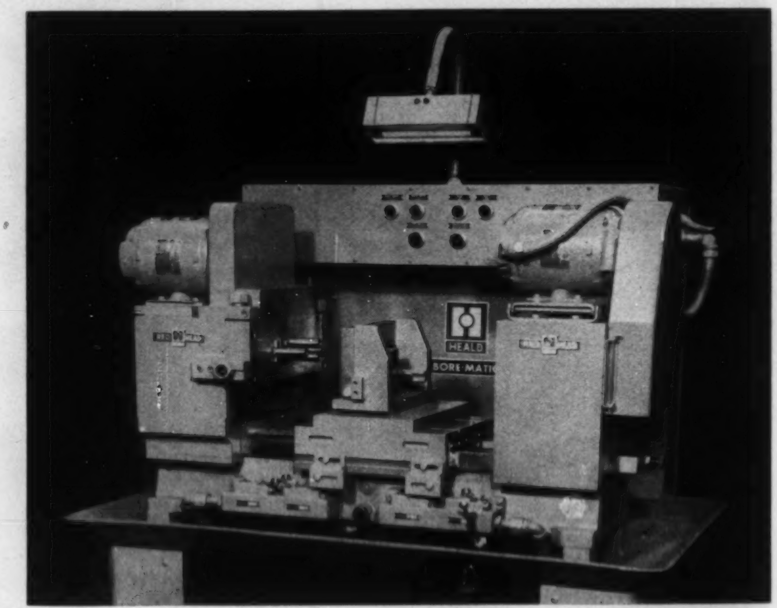
TORRINGTON
BEARINGS

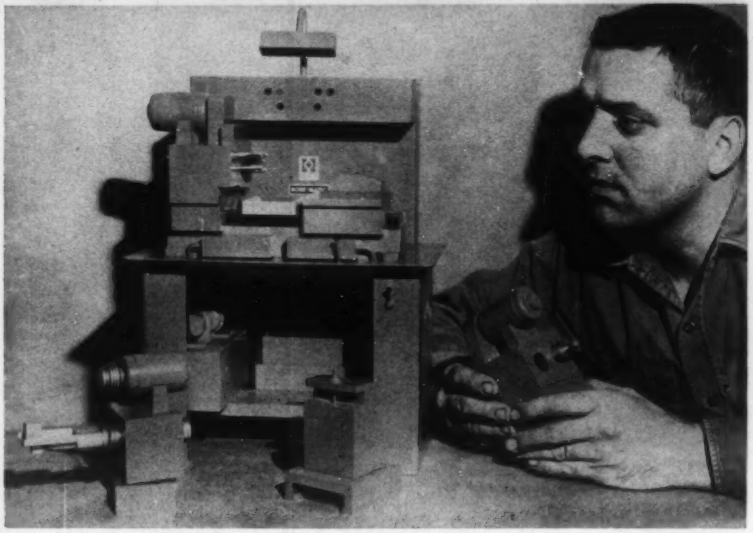
Spherical Roller • Tapered Roller • Cylindrical Roller
Needle • Ball • Needle Rollers

lated part to be treated causes the change in energy. The ion streams induce a temperature of over 500 C with a resultant surface hardening of the part by the diffusion of nitrogen. Precision parts may be ground down to final tolerances before ionitriding with no evidence later of distortion which would necessitate mechanical dressing.

The process so improves the qualities of highly stressed parts that their useful life spans are increased by two to three times. Ionitrided parts show a high degree of surface hardness, high resistance to wear and temperature, high polishing properties, and high fatigue and corrosion resistance.

A joint institute was established by the Northrhine-Westphalia government and Berghaus for the purpose of continuing glow discharge research. Three separate departments within the institute will explore all possibilities for the application of the Berghaus Process to fields other than metallurgical.





BUILDING BLOCK FINISHING MACHINE designed around a number of standard interchangeable units can be assembled into a number of different custom-built setups. Combinations of tooling and fixture equipment perform a variety of boring, facing, turning, chamfering, and grooving operations. Built by The Heald Machine Co., the Model O Bore-Matic features a Multi-Spindle unit with miniature precision boringheads. Any required number of holes on close centers can be finished simultaneously. The machine was developed mainly for instrument work. The scale model of the Bore-Matic shows how the variety of setups can be made.

Plastic Toughie To Challenge Metals

PITTSFIELD, MASS.—A new plastic material tough enough to replace metals in many applications was announced recently by General Electric.

The new material is a polycarbonate resin tradenamed Lexan. Currently it is being evaluated in the form of molded and extruded compounds, film, varnish and coatings. Possible uses include applications previously unsuited to conventional thermoplastic materials.

Unusual impact strength, heat resistance and dimensional stability are claimed to make Lexan a possible substitute for cast metals, ceramics and other plastics in some applications. Molded rods of the new material are rigid enough to withstand hammer blows while being driven as nails.

Lexan resin can be made in a variety of transparent and opaque colors for decorative and functional appliance parts, gears and automotive and telephone accessories.

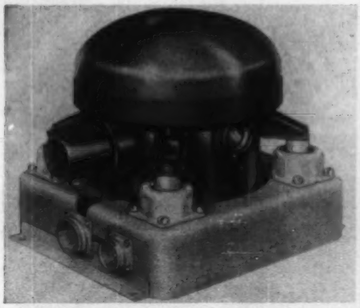
Properties of Lexan

Tensile yield strength, psi	8000-9000
Tensile ultimate strength, psi	9000-10,500
Elongation, per cent	60-100
Flexural strength, psi	11,000-13,000
Water absorption, 24 hr, per cent	0.3
Indentation hardness, Rockwell	M70
Specific gravity	1.20
Dielectric constant (60 cycles)	2.80
Thermal conductivity, cal/sec/sq cm/deg C/cm	4.6×10^{-4}
Coefficient of linear thermal expansion, in./in./deg C	7×10^{-5}
Melting point, deg F	514

Transistorized Compass Has Unusually Low Drift Rate

Sperry Gyrosyn Effective Over Wide Temperature Range

GREAT NECK, N.Y.—A 21-lb, non-floated type compass system is claimed to be six to 15 times more accurate than gyro compasses in general use. The C-11 Gyrosyn, recently announced by Sperry, has shown a random drift rate of only ½-degree per hr even under severe stress and vibration, and has achieved a low of ⅛-degree per hr.



Directional gyro, heart of the C-11 Gyrosyn compass system, weighs 8¼ lb. Its height is 7½ in.; length, 8¼ in.; width, 7¼ in.

The all-transistorized C-11 was developed for long-range navigation of high-speed aircraft. It automatically compensates for earth rate drift of the gyro in either a slaved or unslaved condition.

At latitudes up to 65 degrees, the system provides precise heading indications as a slaved gyro. At higher latitudes, the gyro is unslaved to operate freely. Latitude control is effective from pole to pole and the system operates effectively in a temperature range from −54 to 71 C at altitudes up to 70,000 ft.

First general assembly of the newly formed Cobalt Development Institute has been held recently in Brussels. Aim of the institute is to improve the existing uses of cobalt and to develop new ones.

The institute is represented in the U.S. by the Cobalt Information

(Continued on Page 22)

DRAFTING
TRENDS

"L" angle table cuts fatigue, speeds drafting

The year 1956 saw the introduction of a drafting table destined to change the working habits of many draftsmen. Made by the Hamilton Manufacturing Company and distributed by POST, it is the result of years of experimentation into methods of decreasing drafting fatigue and increasing productivity.

Designed as an "L" this new unit has a complete reference area at a right angle to the drawing board (see photo). Unlike many table arrangements in which the draftsman must turn around completely, or leave his board altogether, the new table *consolidates* the entire working area—the reference desk is never more than a slight turn from the board. This arrangement conserves a surprising amount of time and motion.

Reference desk is 28" x 60" and contains 3 drawers. Board is available in sizes 26" x 40" and 36" x 48".

Like Hamilton's *Auto-Shift* table, the new "L" table adjusts easily and quickly. A hand trip permits slope adjustments to any angle from vertical to horizontal. Another release frees the board for height adjustment through a range of 8". These convenient adjustments are easy to operate and step up efficiency. Where semi-privacy and other unique advantages are needed, the "L" angle table's versatility is especially desirable.

Another motion-saver: "Boardmaster" drafting machine

While very helpful on the board, many drafting machines have characteristics which almost nullify their value—blind spots, awkwardly placed controls, slippage in control settings, etc.

The Universal "Boardmaster" drafting machine solves many of these problems. Its overarm construction allows complete visibility of the protractor at all times. The controls are all *centrally located*—conveniently placed for manipulation by two fingers.

The indexing control has a push-button action that provides automatic indexing every 15°. The vernier clamp has an ingenious double wing lever for locking intermediate angle settings.

Aside from operating ease, the "Boardmaster" meets the highest standards for accuracy. No other drafting machine can match its precision and easy operation.

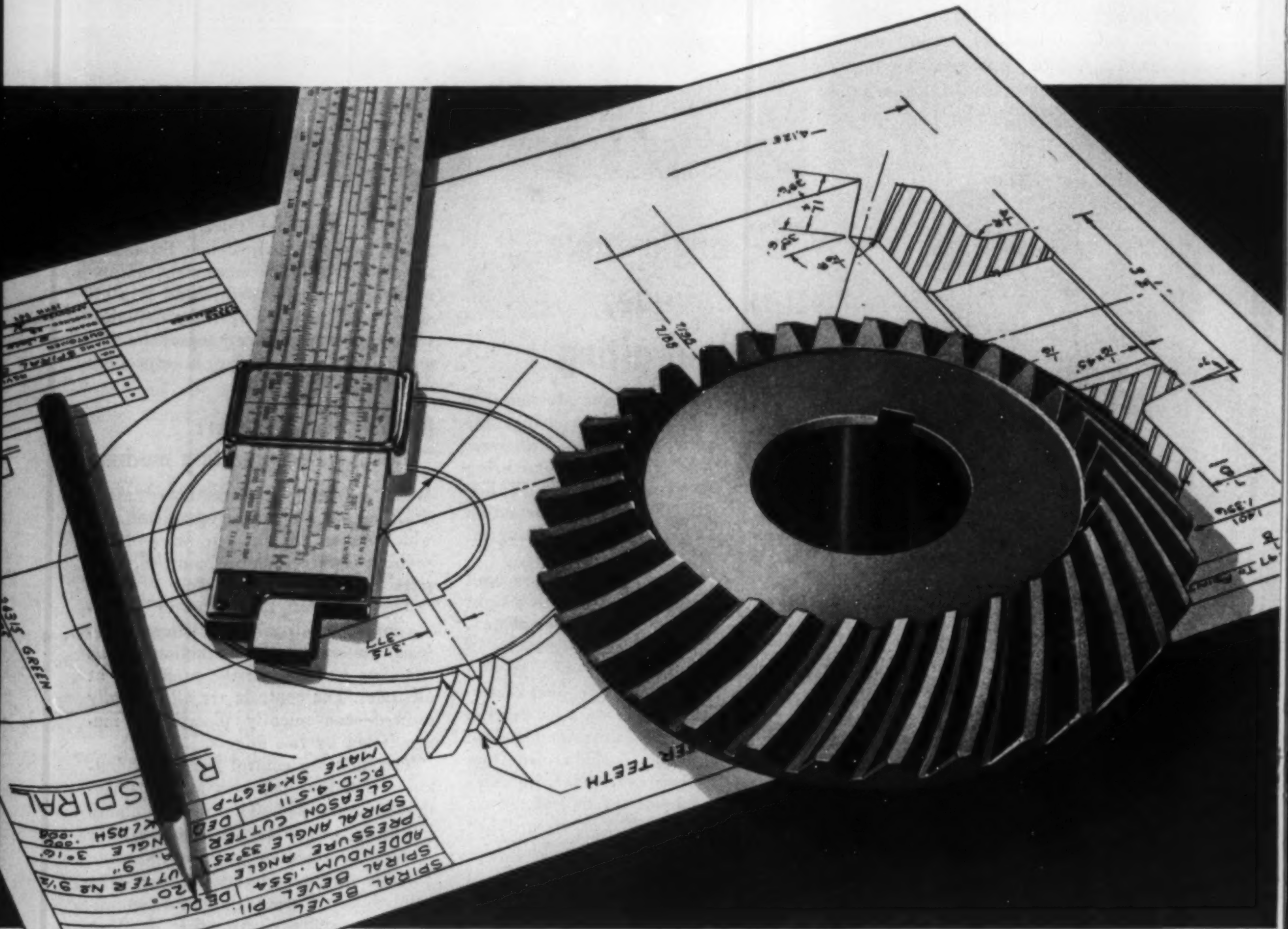
Further information on these items is available from the Reader Service Division of Frederick Post Company, 3652 N. Avondale Avenue, Chicago 18.

POST

SENSITIZED PAPERS & CLOTHS • TRACING & DRAWING MEDIUMS • DRAWING INSTRUMENTS & SLIDE RULES
ENGINEERING EQUIPMENT & DRAFTING SUPPLIES • FIELD EQUIPMENT & DRAFTING FURNITURE

"ENGINEERED QUOTATIONS"

When our engineers study our customers' prints, they look for ways to improve gear performance, ways to simplify gear installations, ways to cut gear costs. When they find a way that they consider better they report it to the customer for his consideration. Very often these "engineered quotations" are accepted. Such careful scrutiny of every engineering and manufacturing step by *gear specialists* is one reason why so many manufacturers use Automotive Gear Division as their "gear department". May we submit an "engineered quotation" on your gear requirements?



EATON

AUTOMOTIVE GEAR DIVISION
MANUFACTURING COMPANY
RICHMOND, INDIANA

GEARS FOR AUTOMOTIVE, FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS
GEAR-MAKERS TO LEADING MANUFACTURERS

Circle 411 on page 19

Reader Information Service

SUBJECT INDEX

Editorial and Advertising content classified by subject and listed by page number for convenience when studying specific design problems. For further information on subjects advertised, refer to advertisement and circle Item Number on a Yellow Card—following page.

Actuators, Edit. 132; Adv. 30, 161
Air traffic control, Edit. 30
Automobile trim, Edit. 10

Balls, Adv. 134
Band saw, articulated, Edit. 100
Bearing materials, Edit. 114
Bearings, ball, Edit. 141; Adv. 36, 47, 147
  miniature, Edit. 141; Adv. 147
  roller, Adv. 13, 47
  sleeve, Adv. 9, 131
  thrust, Edit. 156
Belts, transmission, Adv. 2
Blowers, Edit. 144
Bolt-hole circles, Edit. 111
Books, Edit. 154; Adv. 11, 160
Brakes, Adv. 41, 161
Brass (see Copper and alloys)
Bronze (see Copper and alloys)

Camera, television, Edit. 98
Cam follower, Edit. 128
Carbon and graphite parts, Adv. 158
Castings, Adv. 50
  investment, Adv. 155
  iron, Adv. 34
  nonferrous, Edit. 28; Adv. 131, 134
  shell-molded, Edit. 112
Chain, conveyor, Adv. 54
Clamps, Adv. 138
Classified ads, Adv. 152, 162, 163, 164, 167
Clutches, Edit. 130; Adv. 41, 144
Coils, Edit. 128
Compass, Edit. 15
Computers, Edit. 22
Connectors, electric, Adv. 125, 160
Contactors, Adv. 38
Control systems, electric, Edit. 79, 131
Controls, automatic, Adv. 133, 160
  electric, Adv. 23, 137a, back cover
  hydraulic, Adv. 11, 163
  pneumatic, Edit. 130; Adv. 1, 40
Copper and alloys, Adv. 4, 48
Cores, coil, Edit. 144
Counters, Adv. 143
Couplings, shaft, Edit. 126; Adv. 159
Cylinders, hydraulic, Edit. 94; Adv. 33, 145, 159
  pneumatic, Adv. 33, 138, 145, 159

Drafting equipment, Edit. 148, 150, 152; Adv. 15, 44, 160
Drives, adjustable speed, Edit. 142, 146; Adv. 7, 46

Electric equipment (see specific type)
Electronic equipment, thermal design in, Edit. 84
Engineering department (see Management or Drafting)
Engines, Adv. 62
Extension springs, small, Edit. 102

Fasteners, Edit. 128; Adv. 139, 150, 159
  blind, Adv. 43
  bolts, nuts, screws, Edit. 11, 134; Adv. 21, 27, 31, 43, 67, 136, 139, 154, 157, 161
Filters, Adv. 148
Fittings, pipe, tube and hose, Adv. 63, 161
Forgings, Adv. 32, 119

Gages, pressure, etc., (see also Instruments), Edit. 148
Gaskets, Adv. 39
Gears, Edit. 146; Adv. 16, 28, 163

Heads, steel, Adv. 115
Hose, metallic, Adv. 63
  nonmetallic, Edit. 131; Adv. 127
Hydraulic equipment (see specific type)

Instruments, Edit. 128, 148, 150, 152
Invention, right of, Edit. 81

Jacks, worm gear, Adv. 30

Lenses, plastic, Edit. 128
Lighting, Edit. 136
Limit stop, Edit. 156
Lubricants, Edit. 114
Lubrication equipment, Adv. inside back cover

Machines (see specific type)
Management, engineering, Edit. 109
Meetings, Edit. 10, 31
Metals (see also specific type)
Metals, Adv. 130, 162
Meter-relays, Edit. 128
Motors, electric:
  fractional and integral hp, Adv. 151, 153
  gearmotors, Edit. 136
Motors, torque, Adv. 121

Performance standards, Edit. 74
Pipe, Adv. 70
Pistons, Edit. 80
Plastics, Edit. 14; Adv. 61, 64, 117, 127
Pneumatic equipment (see specific type)
Potentiometers, Edit. 138

MACHINE DESIGN is indexed in Industrial Arts and Engineering Index Service, both available in libraries, generally

SUBJECT INDEX (continued)

Powder metallurgy, Adv. 9, 50, 131
Pumps, Adv. 60, 132, 150
  hydraulic, Edit. 126

Recorders, Edit. 148, 152
Reducers, speed, Adv. 72, inside back cover
Regulators, flow, Edit. 80, 158
  pressure, Adv. 24, 142
Relays, Edit. 126; Adv. 37, 164
Research and development, Edit. 12, 25
Rings, welded, Adv. 149
Rocket fuel, Edit. 22
Rubber, Adv. 69

Satellite monitor, Edit. 5
Seals, Edit. 158; Adv. 66
  mechanical, Adv. 129
Shaft drive, sealed, Edit. 156
Shafts, Adv. 123
  flexible, Adv. inside front cover, 146
Silicones, Adv. 55
Slides, Adv. 138
Spindles, Adv. 138
Springs, Edit. 102; Adv. 52
Stampings, Adv. 71
Standards, performance, Edit. 74
Steel, Adv. 29, 32, 42, 119
  stainless, Adv. 51
Switches, Edit. 126, 128; Adv. 58, 137a, 152
Synchronizing motions with hydraulic cylinders, Edit. 94
Systems, hydraulic, Adv. 140

Thermal design in electronic equipment, Edit. 84
Thermostats, Adv. 133, 135
Tips and techniques, Edit. 108, 110
Torque converters, Adv. 166
Transducers, Edit. 132, 141; Adv. 25
Transmissions, adjustable speed, Edit. 138; Adv. inside back cover
Tubing, Adv. 26, 29, 68, 70, 137, 141

Universal joints, Adv. 57, 136

Valves, Edit. 134; Adv. 142, 156
  hydraulic, Edit. 142; Adv. 163
  pneumatic, Edit. 130; Adv. 1, 40, 138

Welding, Edit. 26
Weldments, Adv. 149

USE A YELLOW CARD
for More Information . . .

CIRCLE ITEM NUMBERS—Throughout the magazine, each advertisement carries an Item Number for use in requesting further information. All product descriptions, announcements and Helpful Literature items are also numbered, and for greater convenience are indexed below by Item Numbers.

EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

Index to New Parts & Helpful Literature
BY ITEM NUMBERS

HELPFUL LITERATURE—descriptions start on page 120

	ITEM NUMBER
Magnesium & Titanium	551
Production Facilities	552
Tube Fittings	553
Measuring Process Variables	554
Control Switches	555
Electric Starter	556
Impulse Counters & Transmitters	557
Turns Counting Dial	558
Vinyl Covering Material	559
Teflon Rod	560
Deburring Brushes	561
Aluminum Coated Steel	562
Press Conveyors	563
Static Switching Systems	564
Miniature Threading Tools	565
Permanent Magnets	566
Proximity Switch	567
Plastic Closures	568
Variable Pitch Drives	569
Electric Motors	570
Electronics Equipment	571
Repeat Cycle Timers	572
Threaded Blind Rivets	573
Magnetic Tapes	574
Transformers	575
Magnet Wire	576

	ITEM NUMBER
Cast Iron	577
Couplings	578
Air Motors	579
Printed Circuit Plastic	580
Panel Meters	581
Adhesives, Coatings, Sealants	582
Thermoplastic Resin	583
Fractured Race Bearings	584
Aluminum Appliance Parts	585
Aircraft Hose & Fittings	586
Hydraulic Pumps	587
Tubing & Pipe	588
Spring Washer Assemblies	589
Electrical Testers	590
Stud Welding	591
Textured Plastic Material	592
Flexible Connectors	593
Stainless Steel Clamps	594
Plastic Pressure Tubing	595
Right Angle Bevel Gears	596
Power Resistors	597
Induction Motors	598
Electronic Equipment	599
Oil-Tight Pushbuttons	600
Small Motor Brushes	601

NEW PARTS & ENGINEERING EQUIPMENT—descriptions start on page 126

	ITEM NUMBER
Subminiature Switches	602
Vane Pumps	603
Flexible Couplings	604
Hydraulic Pump	605
Miniature Relays	606
Cam Followers	607
Miniature Coils	608
Plastic Lenses	609
Self-Retaining Fasteners	610
Meter-Relay Chassis	611
Miniature Chopper	612
Air Valve	613
Magnetic Clutch	614
Teflon Hose	615
Pickup Control Unit	616
Mechanical Adjustor	617
Pressure Transducer	618
Control Valves	619
Hex Nut	620

	ITEM NUMBER
Gearmotors	621
Light Source	622
Potentiometer	623
Truck Transmission	624
Instrument Ball Bearings	625
Pancake Pickup	626
Relief Valve	627
Power Unit	628
Axial-Flow Fan	629
Ring-Type Core	630
Gear Cluster Hubs	631
Variable-Speed Drive	632
Contact Printer	633
Recording Gages	634
Tracing Paper	635
Vibration Calibrator	636
Drafting Tables	637
Recording Instrument	638

MACHINE DESIGN
MAY 2, 1957

Circle item number for information on products advertised or described or copies of literature.

401	426	451	476	501	526	551	576	601	626	651	676	701	726	751
402	427	452	477	502	527	552	577	602	627	652	677	702	727	752
403	428	453	478	503	528	553	578	603	628	653	678	703	728	753
404	429	454	479	504	529	554	579	604	629	654	679	704	729	754
405	430	455	480	505	530	555	580	605	630	655	680	705	730	755
406	431	456	481	506	531	556	581	606	631	656	681	706	731	756
407	432	457	482	507	532	557	582	607	632	657	682	707	732	757
408	433	458	483	508	533	558	583	608	633	658	683	708	733	758
409	434	459	484	509	534	559	584	609	634	659	684	709	734	759
410	435	460	485	510	535	560	585	610	635	660	685	710	735	760
411	436	461	486	511	536	561	586	611	636	661	686	711	736	761
412	437	462	487	512	537	562	587	612	637	662	687	712	737	762
413	438	463	488	513	538	563	588	613	638	663	688	713	738	763
414	439	464	489	514	539	564	589	614	639	664	689	714	739	764
415	440	465	490	515	540	565	590	615	640	665	690	715	740	765
416	441	466	491	516	541	566	591	616	641	666	691	716	741	766
417	442	467	492	517	542	567	592	617	642	667	692	717	742	767
418	443	468	493	518	543	568	593	618	643	668	693	718	743	768
419	444	469	494	519	544	569	594	619	644	669	694	719	744	769
420	445	470	495	520	545	570	595	620	645	670	695	720	745	770
421	446	471	496	521	546	571	596	621	646	671	696	721	746	771
422	447	472	497	522	547	572	597	622	647	672	697	722	747	772
423	448	473	498	523	548	573	598	623	648	673	698	723	748	773
424	449	474	499	524	549	574	599	624	649	674	699	724	749	774
425	450	475	500	525	550	575	600	625	650	675	700	725	750	775

SEND COPIES OF FOLLOWING ARTICLES IN THIS ISSUE

Page No.	Title of Article
....	....
....	....
....	....
....	....

CARD INVALID WITHOUT COMPANY NAME — TYPE OR PRINT

NAME ____________________
TITLE ____________________
COMPANY ____________________
PRODUCT MANUFACTURED ____________________
ADDRESS ____________________
CITY ____________________ ZONE ____
STATE ____________________

Do not use this card after July 2, 1957

MACHINE DESIGN
MAY 2, 1957

Circle item number for information on products advertised or described or copies of literature.

401	426	451	476	501	526	551	576	601	626	651	676	701	726	751
402	427	452	477	502	527	552	577	602	627	652	677	702	727	752
403	428	453	478	503	528	553	578	603	628	653	678	703	728	753
404	429	454	479	504	529	554	579	604	629	654	679	704	729	754
405	430	455	480	505	530	555	580	605	630	655	680	705	730	755
406	431	456	481	506	531	556	581	606	631	656	681	706	731	756
407	432	457	482	507	532	557	582	607	632	657	682	707	732	757
408	433	458	483	508	533	558	583	608	633	658	683	708	733	758
409	434	459	484	509	534	559	584	609	634	659	684	709	734	759
410	435	460	485	510	535	560	585	610	635	660	685	710	735	760
411	436	461	486	511	536	561	586	611	636	661	686	711	736	761
412	437	462	487	512	537	562	587	612	637	662	687	712	737	762
413	438	463	488	513	538	563	588	613	638	663	688	713	738	763
414	439	464	489	514	539	564	589	614	639	664	689	714	739	764
415	440	465	490	515	540	565	590	615	640	665	690	715	740	765
416	441	466	491	516	541	566	591	616	641	666	691	716	741	766
417	442	467	492	517	542	567	592	617	642	667	692	717	742	767
418	443	468	493	518	543	568	593	618	643	668	693	718	743	768
419	444	469	494	519	544	569	594	619	644	669	694	719	744	769
420	445	470	495	520	545	570	595	620	645	670	695	720	745	770
421	446	471	496	521	546	571	596	621	646	671	696	721	746	771
422	447	472	497	522	547	572	597	622	647	672	697	722	747	772
423	448	473	498	523	548	573	598	623	648	673	698	723	748	773
424	449	474	499	524	549	574	599	624	649	674	699	724	749	774
425	450	475	500	525	550	575	600	625	650	675	700	725	750	775

SEND COPIES OF FOLLOWING ARTICLES IN THIS ISSUE

Page No.	Title of Article
....	....
....	....
....	....
....	....

CARD INVALID WITHOUT COMPANY NAME — TYPE OR PRINT

NAME ____________________
TITLE ____________________
COMPANY ____________________
PRODUCT MANUFACTURED ____________________
ADDRESS ____________________
CITY ____________________ ZONE ____
STATE ____________________

Do not use this card after July 2, 1957

MACHINE DESIGN
MAY 2, 1957

Circle item number for information on products advertised or described or copies of literature.

401	426	451	476	501	526	551	576	601	626	651	676	701	726	751
402	427	452	477	502	527	552	577	602	627	652	677	702	727	752
403	428	453	478	503	528	553	578	603	628	653	678	703	728	753
404	429	454	479	504	529	554	579	604	629	654	679	704	729	754
405	430	455	480	505	530	555	580	605	630	655	680	705	730	755
406	431	456	481	506	531	556	581	606	631	656	681	706	731	756
407	432	457	482	507	532	557	582	607	632	657	682	707	732	757
408	433	458	483	508	533	558	583	608	633	658	683	708	733	758
409	434	459	484	509	534	559	584	609	634	659	684	709	734	759
410	435	460	485	510	535	560	585	610	635	660	685	710	735	760
411	436	461	486	511	536	561	586	611	636	661	686	711	736	761
412	437	462	487	512	537	562	587	612	637	662	687	712	737	762
413	438	463	488	513	538	563	588	613	638	663	688	713	738	763
414	439	464	489	514	539	564	589	614	639	664	689	714	739	764
415	440	465	490	515	540	565	590	615	640	665	690	715	740	765
416	441	466	491	516	541	566	591	616	641	666	691	716	741	766
417	442	467	492	517	542	567	592	617	642	667	692	717	742	767
418	443	468	493	518	543	568	593	618	643	668	693	718	743	768
419	444	469	494	519	544	569	594	619	644	669	694	719	744	769
420	445	470	495	520	545	570	595	620	645	670	695	720	745	770
421	446	471	496	521	546	571	596	621	646	671	696	721	746	771
422	447	472	497	522	547	572	597	622	647	672	697	722	747	772
423	448	473	498	523	548	573	598	623	648	673	698	723	748	773
424	449	474	499	524	549	574	599	624	649	674	699	724	749	774
425	450	475	500	525	550	575	600	625	650	675	700	725	750	775

SEND COPIES OF FOLLOWING ARTICLES IN THIS ISSUE

Page No.	Title of Article
....	....
....	....
....	....
....	....

CARD INVALID WITHOUT COMPANY NAME — TYPE OR PRINT

NAME ____________________
TITLE ____________________
COMPANY ____________________
PRODUCT MANUFACTURED ____________________
ADDRESS ____________________
CITY ____________________ ZONE ____
STATE ____________________

Do not use this card after July 2, 1957

FIRST CLASS
Permit No. 36
CLEVELAND, OHIO

BUSINESS REPLY CARD
No Postage Stamp Necessary if Mailed in the United States

—4c POSTAGE WILL BE PAID BY—

MACHINE DESIGN
Penton Building
Cleveland 13, Ohio

Reader's Service Dept.

FIRST CLASS
Permit No. 36
CLEVELAND, OHIO

BUSINESS REPLY CARD
No Postage Stamp Necessary if Mailed in the United States

—4c POSTAGE WILL BE PAID BY—

MACHINE DESIGN
Penton Building
Cleveland 13, Ohio

Reader's Service Dept.

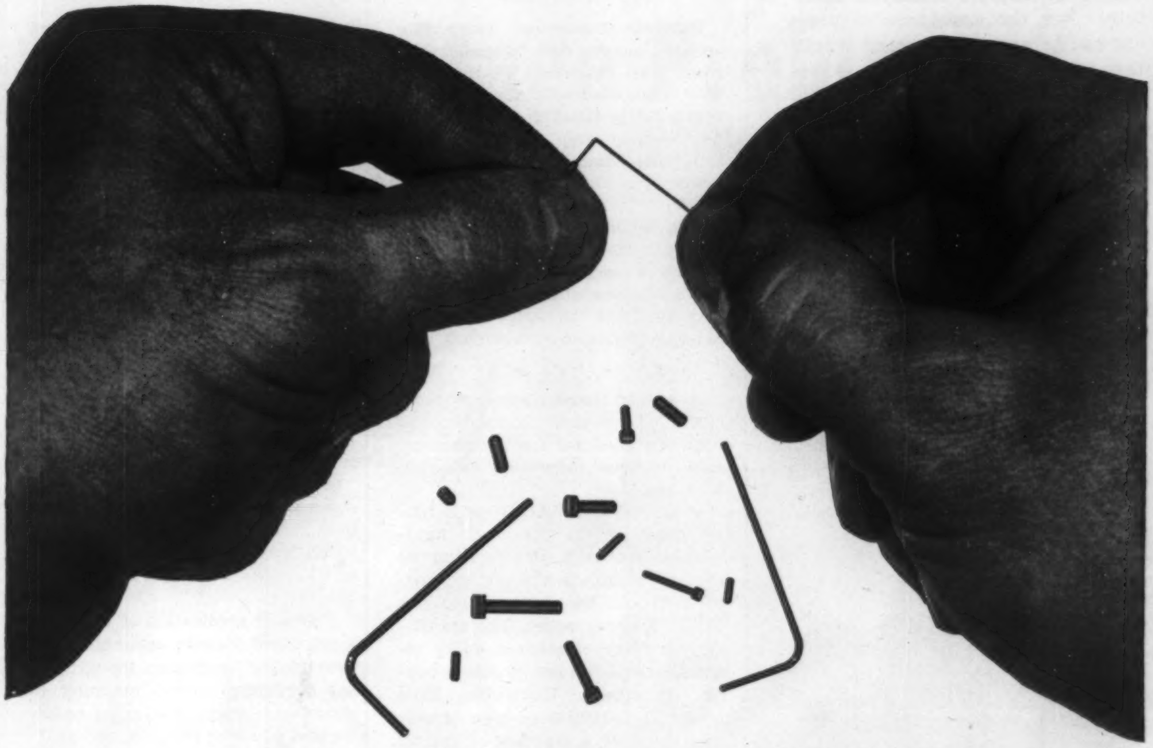
FIRST CLASS
Permit No. 36
CLEVELAND, OHIO

BUSINESS REPLY CARD
No Postage Stamp Necessary if Mailed in the United States

—4c POSTAGE WILL BE PAID BY—

MACHINE DESIGN
Penton Building
Cleveland 13, Ohio

Reader's Service Dept.



If you're miniaturizing . . . you'll save space, time and money with Allen Minicaps and Minisets (#0 thru #3 dia.)

These miniature Allen Hex Socket Cap and Set Screws will let you scale down your product sizes even farther. They're made from Allenoy special alloy steel — so strong that you can safely specify fewer screws or smaller sizes.

Allen Minicaps and Minisets are tiny, but very tough! — true Allens, with deep, clean, strong sockets and uniform Class 3A threads. Minicaps have the Allen knurled "Grip-Head" and are trimmed both on top and *under* the head, for tighter fit and better appearance. Minisets have the improved small-cup Allenpoint that drives deeper and holds tighter.

Because sockets are uniformly true hexagon shape, the key or driver fits tight — makes starting much easier, saves a lot of time in assembly.

Diameters of these miniatures run from #0 through #3. Minicap lengths run from ⅛" through ½", and Miniset lengths from 1/16" through ¼". Also standard in stainless steel. Your Industrial Distributor has them now. He'll show you why these Allens — like all Allens — hold tighter and last longer. Or write for information and samples.

Use Minicaps and Minisets wherever you need dependable fastening in very small assemblies:

TV, radio and telephone equipment • Guided missiles, rockets • Panel meters • Electro-mechanical devices and servo-systems • Computers • Control and operating mechanisms for relays • Cameras • Instruments

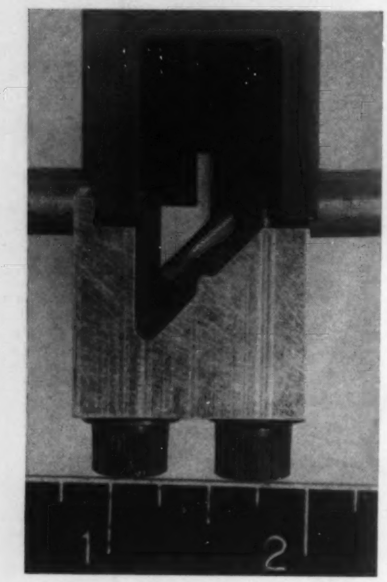
Stocked and sold by leading industrial distributors everywhere

ALLEN **MANUFACTURING COMPANY**
Hartford 2, Connecticut, U.S.A.

ALLEN
HEX-SOCKET SCREWS
HEAD

(*Continued from Page* 15)

Center at Battelle Memorial Institute. For the assistance of present and prospective users of cobalt, the institute will sponsor a research program of fundamental studies and the information center will disseminate technical data.



QUICK SNIP is performed by cartridge-actuated Aerocutters made by Aerojet-General Corp. This special model, designated AGX-1800, is designed to cut four ¼-in. stainless steel tubes carrying corrosive fumes at 150 psi. One cut end of the tubes vents to ambient pressure; the other is sealed by swaging against the Aerocutter anvil. AGX-1800 weighs less than 1 lb; occupies 7.5 cu in.

Computer Comments

Billionth-of-a-second computing speeds based on ferromagnetic films were discussed at the Harvard Computation Laboratory recently. The films are expected to be the next step beyond transistors in speeding up calculators, according to Dr. Herbert Callen of the University of Pennsylvania.

The vacuum tube has been surpassed by the transistor as a component of computing machines, but there is some question as to how long even the transistor and magnetic amplifiers would be used.

• • •

A wholly transistorized, printed-circuit, large-scale computer has been designed for use in research labs, various industries and universities.

Philco's TRANSAC Type S-1000 computer is a compact, lightweight, mobile unit requiring no special installation work or wiring. It can be plugged into any 110-v, 60-cycle outlet. The transistor circuitry eliminates bulky insulation and the heavy power supply equipment. Generating little heat, the S-1000 desk-type console requires only a fraction of the air conditioning equipment normally required.

• • •

Extremely fast conversion of punched-card data into binary serial codes makes a new transcriber 150 times faster than present paper tape inscribers.

Developed by the National Bureau of Standards for use with its high-speed computer, SEAC, the transcriber can handle up to 600 cards per minute. Each card is electronically scanned, and the punched data of its 80 separate columns are transcribed into 4 or 6-digit binary codes.

The transcriber compensates for card skew during reading, hole misalignment, and false readouts during the between-card gap. All timing circuits are keyed to a strobe pulse which is activated by the leading edge of each punched column. Card flow need not be synchronous nor data flow continuous. Output information is available whenever data fields are being read and at no other time.

A self-inhibiting feature allows entire fields of information to be ignored.

• • •

A new high-speed plotter, the Electroplotter S, offers four degrees of freedom in presenting output data in graphic form. Developed by the Benson-Lehner Corp., the machine accepts information from punched paper tape, punched cards, or magnetic tape. It operates at rates of 70 to 100 complete displays per minute.

The simplest output is a two-dimensional *X-Y* point-to-point plot. Additional output includes three single complex displays or any simultaneous combination of the three.

Fields of application of the ElectroplotterS include magnetic and gravimetric mapping, topographical surveying, stress mapping in structures, flight tracing of ballistic and powered missiles, automatic drafting and lofting, and the plotting of aerodynamic pressures and stresses on solid sections.

• • •

Permanent film records of computer results are provided by the new Beattie Varitron Camera. Designed to pick up computer readings directly from cathode ray tube presentation, the camera eliminates time lag.

A micrometer lens focusing mount permits precise focusing, and special field-flattening optics correct distortion. Summations recorded on film by the camera may be enlarged for detailed study.

The Varitron holds 100 ft of 35-mm film which is advanced automatically. Exposures may be made at regular predetermined intervals or at random intervals.

Suitable Rocket Fuels Few and Far Between

Boron Compounds May Be Best Future Fuels

KANSAS CITY, MO.—Most of the useful fuels available today are not suitable as rocket propellants. Only compounds of hydrogen, carbon and boron meet the requirements of desirable characteristics, properties and availability. These will probably form the ultimate rocket fuel.

New boron compounds should produce a fuel having the best handling qualities plus an inherent high heat of combustion. It is unlikely that one all-purpose fuel will ever be developed because of the different requirements of rocket vehicles. Expendable defense missiles can use expensive fuels in great quantities, but passenger craft will require fuels which conform to some economic limit.

These were the conclusions of R. A. Carpenter of Midwest Research Institute. The institute is one of the organizations responsible for the development of a

Dirt, Corrosion, Low Voltage Problems?

Allis-Chalmers Size 6 starter, NEMA 1 enclosure.

the answer:

Allis-Chalmers "dc operated" ac contactors*

Dc operators in Allis-Chalmers control assure dependable performance because they are not affected by dirt or corrosion on the armature face. Positive magnetic operation reduces contact pitting — eliminates hum and chatter—prolongs mechanical life. The operator picks up at 65% of rated voltage — holds in with as little as 35%.

For Any Low Voltage, High Horsepower Application . . . Allis-Chalmers Modern Control — Sizes 4, 5 and 6

Advanced Electrical Design

ACBO arc-centering blowout sharply curtails arcing time, greatly prolongs contact and chute life — without blowout coils.

Simplified Mechanical Design

Streamlined clapper-type construction permits natural arc rise in arc chute. Sensible enclosure dimensions provide ample wiring space. Easy accessibility simplifies maintenance.

For detailed information on this complete line of modern control, call your A-C Control Distributor or A-C District Office. Or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

*Self-contained ac to dc circuit. Standard in Size 6, optional in sizes 4 and 5.

ALLIS-CHALMERS

A5372

ACBO is an Allis-Chalmers trademark.

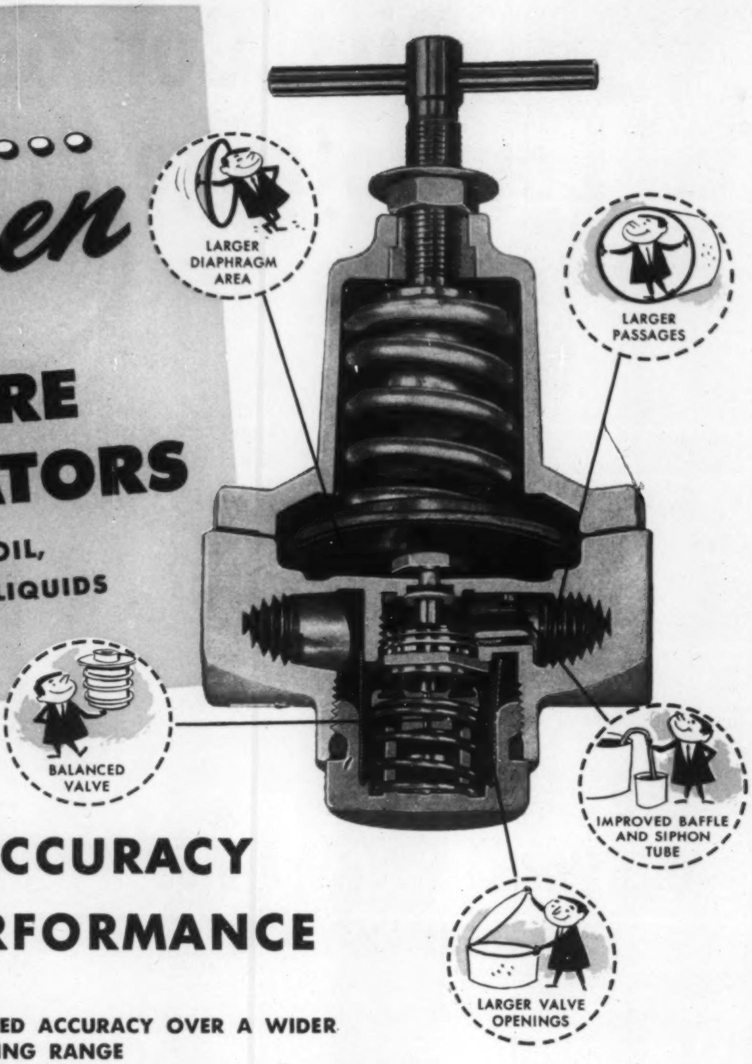
Circle 413 on page 19

NEW...

Norgren

PRESSURE REGULATORS

FOR AIR, WATER, OIL, NON-CORROSIVE LIQUIDS AND GASES

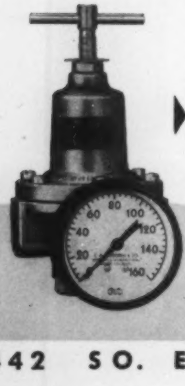


LARGER DIAPHRAGM AREA
LARGER PASSAGES
BALANCED VALVE
IMPROVED BAFFLE AND SIPHON TUBE
LARGER VALVE OPENINGS

GREATER ACCURACY
BETTER PERFORMANCE

- **IMPROVED ACCURACY OVER A WIDER OPERATING RANGE**
- **GREATER ACCURACY OF REGULATED PRESSURE** even with widely fluctuating line pressure and rapidly varying flow.
- **LARGER FLOW CAPACITY**
  - a. Balanced Valve Construction
  - b. Greater Effective Diaphragm Area
  - c. Improved Baffle and Siphon Performance
  - d. Larger Passages
  - e. Larger Valve Openings
- **RELIEVING AND NON-RELIEVING TYPES AVAILABLE FOR AIR**

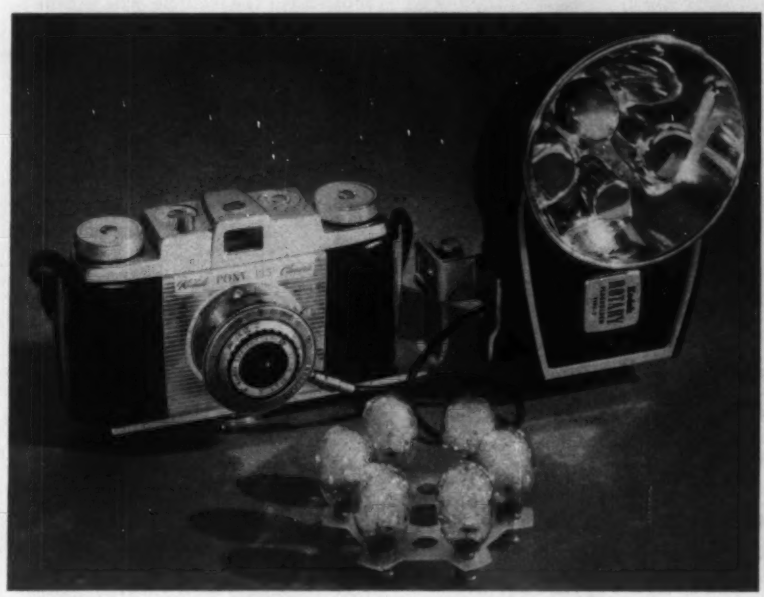
For complete information on all your regulator needs, ⅛" to 2" inclusive, call your nearby Norgren Representative listed in your telephone directory — or WRITE FACTORY FOR LITERATURE.



C. A. NORGREN CO.

3442 SO. ELATI STREET • • • ENGLEWOOD, COLORADO

new high-energy fuel called HiCal. It is claimed that HiCal "will multiply the range of jet planes or missiles and permit flying at altitudes substantially higher than any aircraft can reach today without rocket power." HiCal is a combination of hydrogen, carbon and boron, in which the hydrogen is chemically locked in liquid form.



SIX SHOOTER, Kodak Rotary Flasholder gives camera fans six rapid flash pictures with rotating bulb magazine. Extra carrier disc gives total of 12 bulbs for quick use. Disc is rotated to fresh bulb after each picture and removed as a unit. Flasholder, in two models, fits most cameras.

Rockets To Gather New Data At Extreme Altitudes

But Return Vehicles Must "Bring 'Em Back Alive"

BALTIMORE, MD.—Preliminary design studies concerning the feasibility of recovering the scientific payloads of very high altitude rockets have been reported recently by a research subsidiary of the Glenn L. Martin Co. Purpose of the rocket flights will be to extend current information on the nature of outer space. Hitherto undetected components of primary cosmic radiation may be found at great heights above the earth if sensitive emulsion sheets exposed to the radiation can be returned to earth undamaged.

The design studies show that a rocket payload weighing about 150 lb can be projected more than 2000 miles into space, using rocket components which are available today. Of this 150 lb, one-third will be useful from the scientific standpoint; the other two-thirds will be structure and protection required for recovery.

In the recovery of the payload, the emulsions must be protected from the very high temperatures resulting from re-entry into the earth's atmosphere, and the structure must be capable of withstanding very high decelerations. In addition to the emulsion sheets and their handling structure, the total payload must include a heat-resistant shell, a parachute for lowering the payload gently to earth, and a radio beacon to locate it after it has landed.

Duration of powered flight of the rocket will be less than 5 min-

Miniature Pressure Transducers for operation to +400°F.

Temperature compensated over 465°F. interval

0.01%/°F. thermal coefficient of sensitivity from −65° to +400°F.

0.01%fs/°F. thermal zero shift from −65° to +400°F.

No cement or resin pressure seals

Homogeneous sensing diaphragm surface

Statham unbonded strain gage transduction

Minimum response to vibration or acceleration

Pressure adapters for closed line applications

Absolute Pressure Transducers
0-5 to 0-500 psia – Model PA260TC

Gage Pressure Transducers
0-5 to 0-500 psig – Model PG260TC

Differential Pressure Transducers
0-5 to 0-500 psid – Model PL260TC
±2.5 to ±25 psid – Model PM260TC

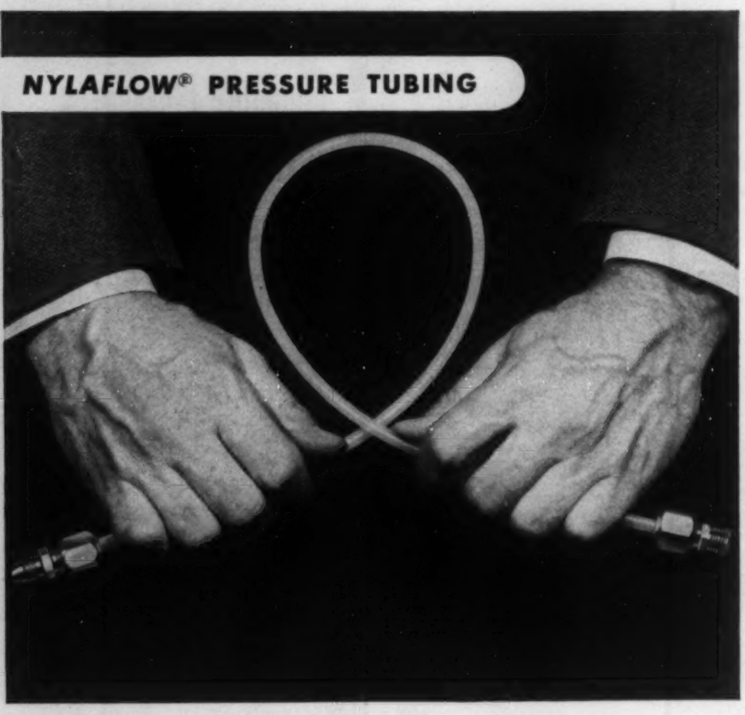
When the transducer is a Statham, pressure measurements at elevated temperature are made with accuracy and confidence.

Complete specifications available upon request.

Please wire or telephone us collect whenever we may be of service.

Statham
LABORATORIES
12401 W. Olympic Blvd., Los Angeles 64, Calif.

Circle 415 on page 19



NYLAFLOW® gives you high strength, long flex life, light weight

NO OTHER tubing offers the same unusual combination of physical properties with ease of installation . . . to provide lower costs, long tubing life.

Nylaflow is a tough, flexible polyamide tubing being used successfully in many industries for air lines, grease and oil lines, low pressure hydraulic lines, beverage lines and other applications.

These are *Nylaflow's* unique characteristics:

- High burst pressure at low cost
- Extremely long flex life
- Tough—wear and crush resistant
- Hornlike, can be used with standard fittings
- Easily bent for installation—can be held with clips or permanently pre-bent with heat
- Serves over wide temperature range
- Resistant to solvents, oils, alkalis, hydraulic fluids
- Odorless, tasteless, non-corrosive, non-toxic, fungus resistant

The design and performance capabilities of Nylaflow are outlined in a new bulletin available from The Polymer Corporation of Pa., Reading, Pa. Write for your copy today.

See POLYMER booth No. 832
Design Engineering Show
New York City May 20-23

THE POLYMER CORPORATION OF PENNA.
Reading, Pa.
Export: Polypenco, Inc., Reading, Penna., U.S.A.

POLYPENCO

POLYPENCO nylon, POLYPENCO Teflon†, NYLAFLOW® & NYLATRON® GS. †Du Pont Trademark

Circle 416 on page 19

utes. For the remainder of the trip, the payload will be decelerating and reaccelerating in the earth's gravitational field in a free-fall. The payload will spend about 40 minutes above the atmosphere. Upon re-entering the earth's atmosphere, the vehicle will attain a top speed of about 13,000 mph.

VEST POCKET VIEWER by Ansco has frosted screen for backlighting 35-mm slides. Magnified eyepiece gives clear enlargement. Folded size is about $3\frac{1}{2}$ in. sq by 1 in. Viewer is available in four colors.

Fast Arc Welding Joins Thick Plates in Single Pass

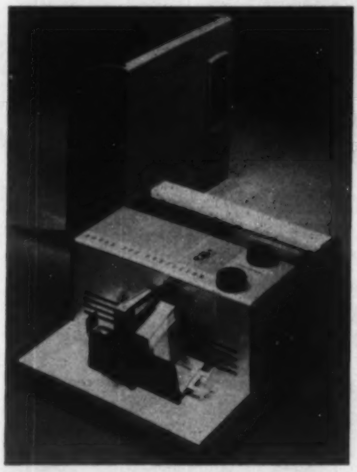
Double-Duty CO_2 Helps Add to Arc Temperature

PHILADELPHIA, PA. — A new arc welding process introduced recently by National Cylinder Gas Co. is claimed to deposit weld metal three to twelve times faster than manual "stick electrode" welding and 33 per cent faster than established semiautomatic methods. Called Dual Shield, the process employs a flux-core electrode in combination with a shielding of carbon dioxide gas. It is claimed to give sound, low-cost welds on any type of mild steel, including rim and T-1 steels, at a high rate of weld metal deposit and with unusually deep penetration.

Dual Shield electrodes are said to be the first to have built-in granular flux additives that protect the work from atmospheric impurities. This flux includes an ionizer to stabilize the electric arc, a deoxidizer that permits welding mill-run steel without cleaning it first, and a slag-forming agent. The new process employs carbon dioxide gas in a dual role. It excludes contaminating air from the arc and molten metal. It also introduces a measured portion of oxygen directly into the weld pool where it combines chemically with certain flux additives to clean and purify the metal being welded.

The result is a stable arc 1000 degrees hotter than the average 9000-degree welding arc. It is claimed that a single pass with the welding gun can weld the full thickness of a ½-in. steel plate.

Adoption of the new process involves an NCG SA series welding gun, a Sureweld electronic control unit, a welding transformer, a spool electrode and gas supply, and the training of an operator.

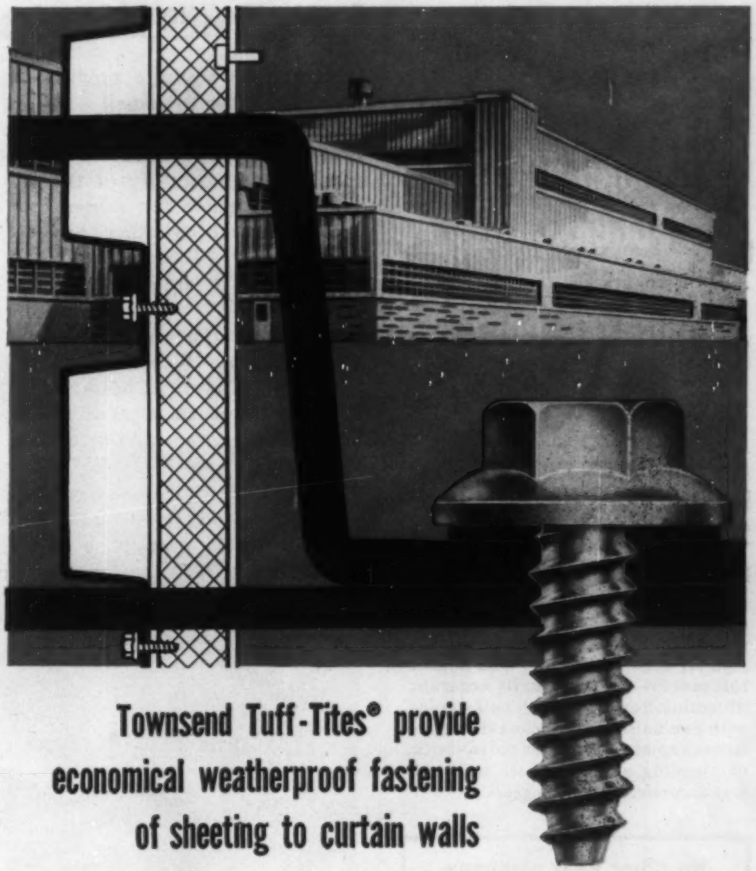


ON - THE - TOP - CONTROLS are convenient for operators of this new Kodak 300 projector. Model 1 Readymatic slide-change system rotates slides into position. Model 2 has a 36-compartment magazine for permanent storage.

Multiple-Explosive Rockets Will Measure the North Wind

Spot Checks Under Way In Three Spots

WASHINGTON, D. C.—The army is now firing high-altitude rockets from the top of the world to map the North Wind near its source. The experiments are planned by Army scientists at the Signal Corps Engineering Laboratories. Results are expected to



Townsend Tuff-Tites® provide economical weatherproof fastening of sheeting to curtain walls

Townsend Tuff-Tite fasteners provide weatherproof fastening of exterior sheeting to insulated panels used in curtain wall and roof construction. Leakage is eliminated by the Tuff-Tite's integral undercut hex head and washer construction and by the pre-assembled conical shaped neoprene washers which fill the holes.

An outstanding application of Tuff-Tites in curtain wall construction is the "A" panel made by Elwin G. Smith & Co., Emsworth, Pa. These panels are made with a number of different surfaces and have been installed by Elwin G. Smith on buildings in varying climates from New England to Texas.

Tuff-Tites are available in both stainless and carbon steels in a number of types and lengths. They are equally suitable for crown or valley fastening because of their excellent sealing qualities and may be used with aluminum, galvanized steel, stainless steel, protected metals, fiberglass plastic or asbestos siding and roofing.

For more information on these economical, weatherproof fasteners, write to Townsend Company, P.O. Box 237-E, New Brighton, Pa., asking for Bulletin TL-107a.

See Tuff-Tites Demonstrated At The Design Engineering Show—Booth 1139

The Fastening Authority
Townsend
COMPANY • ESTABLISHED 1816
NEW BRIGHTON, PENNSYLVANIA
Sales Offices in Principal Cities
Cherry Rivet Division • Santa Ana, California

In Canada: *Parmenter & Bulloch Manufacturing Company, Ltd., Gananoque, Ontario*

Circle 417 on page 19

You can have all the advantages of

GROUND TOOTH ACCURACIES AT NO GREATER COST

- - if you are now using case-hardened gears, starting at about 3″ dia., in quantities of 12 to 25 or more of a kind, depending on size.

It's a Fact! Sier-Bath can supply ground tooth gears to the one best design for each application, with defined tolerances—dimensionally accurate, distortion-free, dependably uniform and with fine finish . . . at prices that make it uneconomical to risk the noise, shock, overloading and premature failure of less accurate, unground gears.

No other gear company can now give you PRECISION CROWN-GROUND SPUR and HELICAL GEARS to 12″ diameter, 4 pitch

ADVANTAGES: In spite of great overloads and misalignment, or deflection due to overloading, Sier-Bath crown-ground gears retain centralized tooth loading for far greater strength, opening new opportunities for accomplishment in your machines. Investigate!

—— Send us specs and prints for study and quotation—or have a Sier-Bath gear specialist call to discuss the steps that will make us your ideal gear department.

***Sier-Bath* GEAR *and* PUMP CO., Inc.**
9237 Hudson Blvd. North Bergen, N. J.
Established 1905 Member A.G.M.A.
Also Manufacturers of Rotary Pumps and Flexible Gear Couplings

Sier-Bath
PRECISION GEARS

All kinds of gears—
all materials
Made—cut—shaved—
ground tooth
42″ maximum diameter
12 or more of a kind, depending on size.

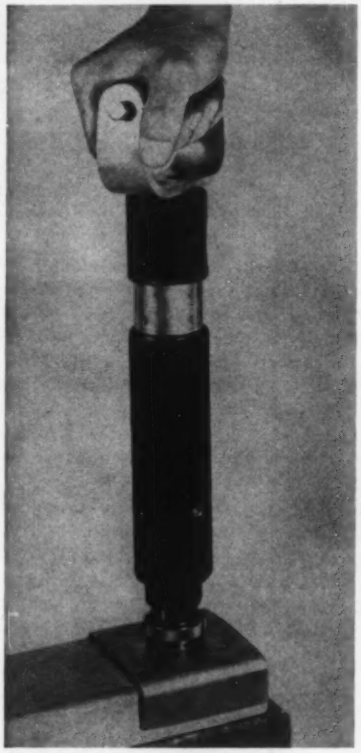
Circle 418 on page 19

lead to more accurate predictions of cold weather to come.

The rockets will reveal for the first time the precise direction, speed and temperature of the icy winds responsible for winter cold spells as well as other high-altitude winds. These currents will be explored to an altitude of 80 miles.

Rocket for the experiments will be the Aerobee-Hi model by Aerojet-General Corp. The Aerobee-Hi holds the world altitude record of 163 miles for a single-stage "boosted" rocket.

The first specially-equipped Aerobee has already been fired from Fort Churchill, deep in northern Canada. Nine more launchings will follow during the 1957-58 International Geophysical Year.



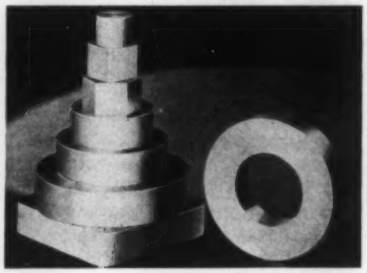
POWDER-ACTUATED fastening tool is industry's first piston-driven model. Blank cartridges drive studs through wood and metal objects, fastening them to concrete. Studs are pushed into the work surface rather than shot in. Made by the Velocity Power Tool Co., the 6-lb Stud Hammer is completely recoilless, and there are no escaping barrel gases.

Like Fourth of July skyrockets, the Aerobees spray 18 packets of high explosives into the air at preset intervals during the ascent. As the 4-lb charges explode, sensitive instruments on the ground record the blasts. The time intervals between the explosions and the arrival of the sounds on earth are the raw data for computations.

The Signal Corps rocket program at Fort Churchill is the second leg of an Army worldwide spot-check of high altitude mass currents. Extensive observations of western air currents have been made at White Sands, New Mexico. Another series of launchings is planned at Guam, in the West Pacific.

High-Speed Casting Produces Superior Finish

CLEVELAND, O.—Exceptionally high casting speeds and superior surface finish are claimed to be obtainable with the new Apex-Goss process for the continuous casting of nonferrous metals. The process has been developed jointly by the Apex Smelting Co. and Goss Laboratories.

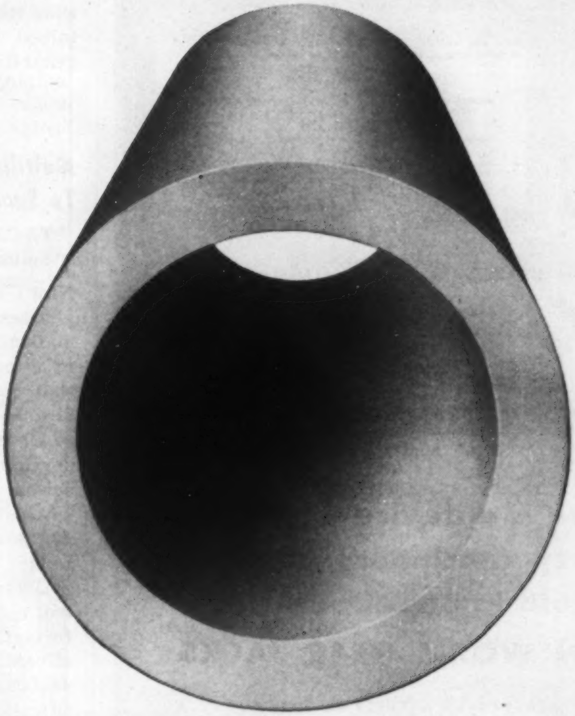


Representative cast sections include tubular and standard shapes.

To date, the method has produced a variety of shapes in aluminum and aluminum alloys. Results are said to show that any standard shape and small cross sections can be easily cast; that grain size is accurately controlled and consistently uniform.

Because of the controlled grain

How to step up production of hollow parts



Start with TIMKEN® seamless steel tubing—*no hole to drill!*

MAKING hollow parts from bar stock slows down production. You have to bore out the center hole. That takes extra time, increases production costs. But with Timken® seamless steel tubing, *the hole's already there.* Finish boring is your first production operation. You save a big step—increase production, reduce costs. With less metal to machine away you get more parts per ton of steel.

Because Timken seamless steel tubing eliminates one boring operation, it frees screw machine stations for other jobs. You add machining capacity without adding machines.

Timken seamless tubing also gives you a better quality finished product. The piercing process by which Timken seamless tubing is made is basically a forging operation. It gives you fine forged quality—a uniform spiral grain flow for greater strength and a refined grain structure. And we maintain this uniform quality through rigid quality control—tube to tube, heat to heat, order to order.

And to further increase your steel savings, Timken Company engineers will recommend the most economical tube size for your hollow parts job—a size guaranteed to clean up to your dimensions.

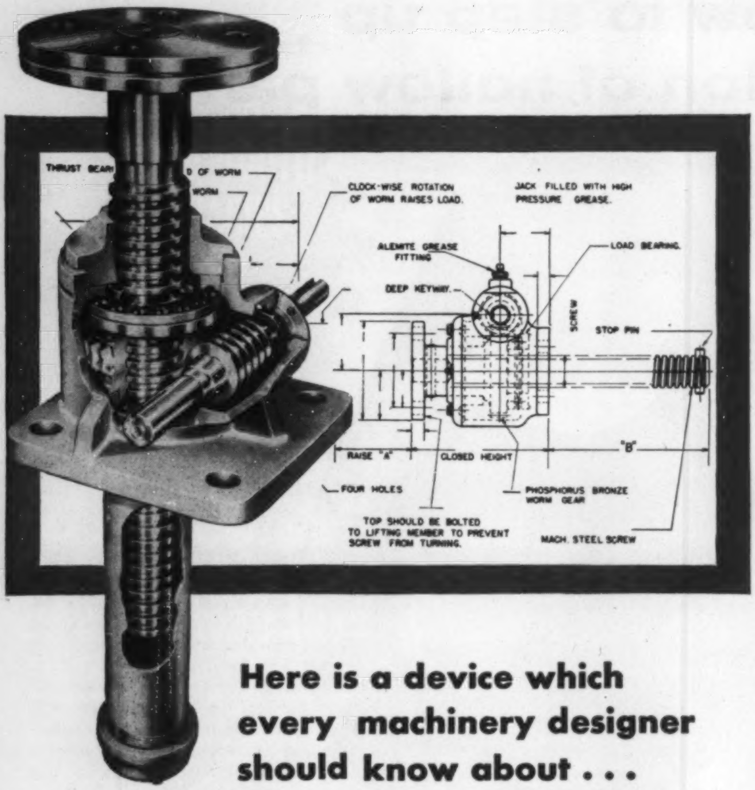
The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

TIMKEN *Fine Alloy* **STEEL**

TRADE-MARK REG. U. S. PAT. OFF.

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS STEEL TUBING

Circle 419 on page 19



THRUST BEARI
D OF WORM
WORM
CLOCK-WISE ROTATION OF WORM RAISES LOAD.
JACK FILLED WITH HIGH PRESSURE GREASE.
ALEMITE GREASE FITTING
LOAD BEARING.
DEEP KEYWAY.
SCREW
STOP PIN
RAISE "A"
CLOSED HEIGHT
"B"
FOUR HOLES
PHOSPHORUS BRONZE WORM GEAR
TOP SHOULD BE BOLTED TO LIFTING MEMBER TO PREVENT SCREW FROM TURNING.
MACH. STEEL SCREW

Here is a device which every machinery designer should know about . . .

DUFF-NORTON WORM GEAR JACKS

Duff-Norton worm gear jacks provide a purely mechanical means for accurate positioning of loads weighing as much as several hundred tons and maintaining them indefinitely without creep. They will operate in any position, and functioning as components of machinery and equipment they can raise and lower loads, apply pressure or resist impact. Jack capacities range from five to 50 tons. When two or more jacks are connected by means of shafting and mitre gear boxes they lift in unison, even when the load is unevenly distributed. They are available with standard raises up to 25 inches, and will provide exactly the same raise for years without adjustment. Worm gear jacks are suitable for operation at ambient temperatures up to 200°F.

Thousands of these jacks are in use on feeding tables, tube mills, welding positioners, pipe cut-off and threading machines, testing equipment, aircraft jigs, loading platforms, rolling mills, conveyor lines, arbor presses, and numerous other types of equipment. If you have a positioning problem, write for complete information, requesting bulletin AD-34-V, which includes drawings and full specifications.

See these jacks at the Design Engineering Show—Booth 1704

Duff-Norton Jacks

DUFF-NORTON COMPANY
P. O. Box 1889 • Pittsburgh 30, Pennsylvania
COFFING HOIST DIVISION: Danville, Illinois

Ratchet Jacks, Screw Jacks, Hydraulic Jacks, Special Worm Gear Jacks, Ratchet Hoists, Electric Hoists, Load Binders, Spur Gear Hoists

Circle 420 on page 19

size, it is also claimed that lower pressures can be used to extrude aluminum cast by this process. A wide range of casting shapes is attained by using an oil-lubricated graphite mold.

Multilingual Electronic Device To Speed Air Traffic Control

TACAN System Talks Canned Conversation

NEW YORK, N. Y.—Words and phrases are now transmitted automatically at the touch of a button in a new communications system that holds the prospect of greater air safety through better control of air traffic. The system has been developed by Federal Telecommunication Laboratories and is called TACAN (Tactical Air Navigation) Automatic Reporting and Data Link.

Using TACAN, air traffic control centers can exchange vital information with as many as 120 aircraft in just 6 seconds. Representative information is plane identification, position, speed, course and altitude. The system enables transmission of traffic control assignments in the same terms; at the same speed. Currently TACAN is being integrated with VORTAC, the very high frequency omnirange system, which will soon become the U.S. Common Air Navigation System.

The instrument panel on TACAN Data Link-equipped aircraft contains a number of dual-purpose instruments which simultaneously advise pilots of existing conditions and display orders from the ground station.

Panel instruments enable the pilot and ground controller to exchange messages on routine matters through a unique pushbutton arrangement. Each has at his command a "library" of 31 messages.

Should the ground controller want the pilot to let "wheels down," "hold," or "proceed," he pushes the appropriate button and the order appears in word form on the pilot's instrument. Similarly, if the pilot wants to inform the ground station that he is "landing," or "holding," he presses the appropriate button on his instrument panel to convey the information.

An important feature of the TACAN system is the elimination of the language difficulty for pilots flying international routes. Messages transmitted from the ground appear in the cockpit as a printed message in the pilot's language. The same transmission can appear in English in one plane, and in French, German, or Japanese, in other planes.

Meetings

AND EXPOSITIONS

May 15-17—
Radio - Electronics - Television Manufacturers Association. Annual Meeting to be held at the Sheraton Hotel, Chicago. Additional information is available from association headquarters, 1721 De Sales St. N. W., Washington 6, D. C.

May 16-18—
Society of Naval Architects and Marine Engineers. Annual Spring Meeting to be held at the Lafayette Hotel, Long Beach, Calif. Additional information can be obtained from society headquarters, 29 W. 39th St., New York 18, N. Y.

May 19-23—
American Society of Mechanical Engineers. Oil and Gas Power Conference to be held at the Kentucky Hotel, Louisville. Additional information can be obtained from ASME headquarters, 29 W. 39th St., New York 18, N. Y.

May 20-21—
Eighth Annual Appliance Technical Conference to be held in the Engineering Societies Bldg., Detroit. Conference is sponsored by the Subcommittee on Domestic Appliances of the American Institute of Electrical Engineers. Further information is available from AIEE headquarters, 33 W. 39th

Socket Screw Keys & Kits
Socket Pipe Plugs
"Saf-Lok" Socket Screws
"Led-Lok" Socket Cap Screws
Socket Shoulder Screws
Flat Head Socket Screws
Socket Cap Screws
Socket Set Screws
8 Star Performers FOR YOUR TEAM!

Member ASMMA

Blue Devil SOCKET SCREW PRODUCTS

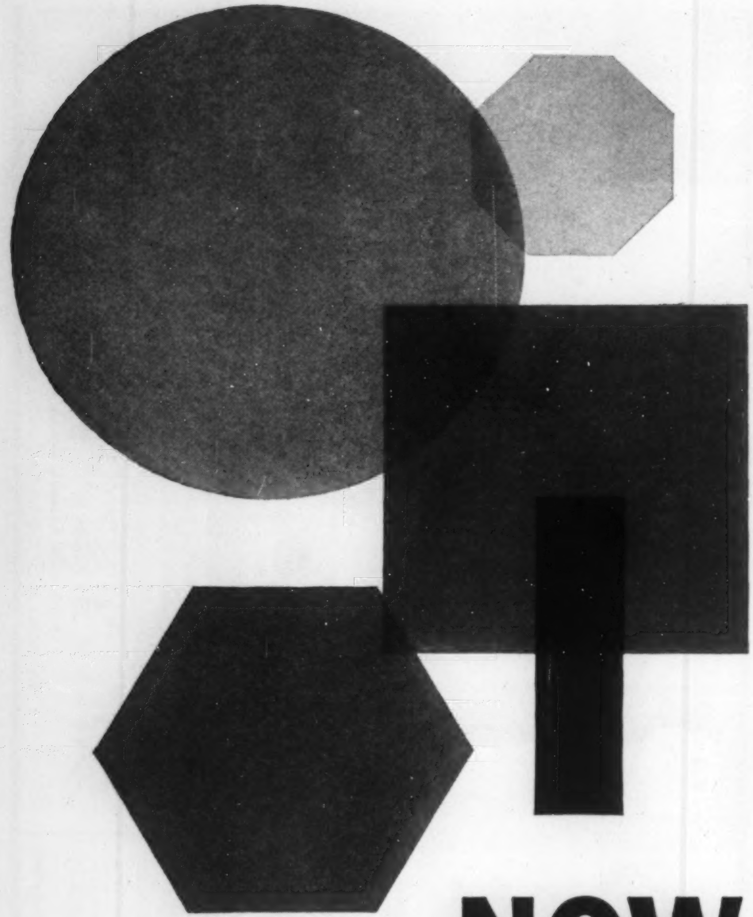
I'M YOUR BLUE DEVIL DISTRIBUTOR
. . . helping you with socket screw problems is my business. We stock the complete Blue Devil line for fast service, immediate delivery. Let's get acquainted!

Silver Anniversary—25 Years of Socket Screws Exclusively

You'll find Blue Devil Socket Screws give you outstanding quality plus a broad range of styles. Included in this line are Led-Lok and Saf-Lok, exclusive vibration-proof socket screws. Why not call your distributor today?

Sold Only Through Authorized Industrial Distributors

SAFETY SOCKET SCREW COMPANY
6510 North Avondale Avenue, Chicago 31, Illinois
Warehouses at: Los Angeles, San Francisco, Detroit, New Haven, Conn.



when you need it **NOW**

call Wheelock, Lovejoy!

For quick action — *regardless of the size of your order* — call Wheelock, Lovejoy for alloy steel bars, billets or forgings. Whatever size, shape or heat treatment you may need, you can get it *when you need it* by ordering directly from the W-L warehouse nearest you.

Expert metallurgists will help you select from our own HY-TEN steels or the standard AISI or SAE grades.

Write today to our Cambridge office for your *free* Wheelock, Lovejoy Data Sheets. They contain complete technical information on grades, applications, physical properties, tests, heat treating, etc.

Warehouse Service — Cambridge • Cleveland • Chicago
Hillside, N. J. • Detroit • Buffalo • Cincinnati • *In Canada* — Sanderson-Newbould, Ltd., Montreal & Toronto.

WHEELOCK, LOVEJOY & COMPANY, INC.
133 Sidney Street, Cambridge 39, Mass.

St., New York 18, N. Y.

May 20-23—
Design Engineering Show to be held at the Coliseum, New York. Second Annual Design Conference, to be held in conjunction with the show, is sponsored by the Machine Design Div. of ASME. Further information on the show is available from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

May 22-23—
American Iron and Steel Institute. Annual Meeting to be held at the Waldorf-Astoria Hotel, New York. Additional information can be obtained from institute headquarters, 350 Fifth Ave., New York 1, N. Y.

May 22-24—
American Society for Quality Control. 11th Annual Convention to be held in the Masonic Temple, Detroit. Further information is available from R. V. Ward, Canadian Industries Ltd., P. O. Box 10, Montreal, P. Q., Canada.

June 2-5—
American Gear Manufacturers Association. Annual Meeting to be held at the Homestead, Hot Springs, Va. Further information can be obtained from association headquarters, 1 Thomas Circle, Washington 5, D. C.

June 2-7—
Society of Automotive Engineers. Summer Meeting to be held at Chalfonte-Haddon Hall, Atlantic City, N. J. Further information is available from society headquarters, 485 Lexington Ave., New York 17, N. Y.

June 3-5—
American Society of Refrigerating Engineers. 53rd Annual Meeting to be held at Hotel Fontainebleau, Miami Beach, Fla. Additional information can be obtained from society headquarters, 234 Fifth Ave., New York 1, N. Y.

June 9-13—
American Society of Mechanical Engineers. Semiannual Meeting to be held at the Sheraton-Palace Hotel, San Francisco. Further infor-

mation can be obtained from society headquarters, 29 W. 39th St., New York 18, N. Y.

June 11-13—
Third Western Plant Maintenance and Engineering Show and Conference to be held at the Civic Auditorium, San Francisco. Additional information is available from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

June 13-14—
Malleable Founders' Society. Annual Meeting to be held at the Broadmoor Hotel, Colorado Springs, Colo. Additional information is available from society headquarters, 1800 Union Commerce Bldg., Cleveland 14, O.

June 16-20—
American Electroplaters' Society. Annual Meeting to be held at Sheraton-Mt. Royal Hotel, Montreal, P. Q. Further information can be obtained from society headquarters, 445 Broad St., Newark, N. J.

June 16-21—
American Society for Testing Materials. 60th Annual Meeting to be held at Chalfonte-Haddon Hall, Atlantic City, N. J. Further information is available from society headquarters, 1916 Race St., Philadelphia 3, Pa.

June 17-21—
American Society for Engineering Education. Annual Meeting to be held at Cornell University, Ithaca, N. Y. Additional information can be obtained from society secretary, W. Leighton Collins, University of Illinois, Urbana, Ill.

June 19-22—
Drop Forging Association. Annual Meeting to be held at Grand Hotel, Mackinac Island, Mich. Additional information can be obtained from the association, 419 S. Walnut St., Lansing 33, Mich.

June 23-25—
Alloy Casting Institute. Annual Meeting to be held at the Homestead, Hot Springs, Va. Additional information is available from institute headquarters, 32 Third Ave., Mineola, N. Y.

YOUR CYLINDER ORDER SHIPPED

IN 24 HOURS OR LESS!

—LET CARTER CARRY YOUR INVENTORY!

ANY BORE SIZE
ANY MOUNT
ANY STROKE

AIR OR HYDRAULIC

CARTER CYLINDERS

Get your cylinders *now*, when you need them. No need to lose production because of poor delivery! Carter will *ship your cylinder order in 24 hours or less*, to satisfy your needs. And when you buy Carter cylinders, you buy quality—rugged, dependable cylinders.

Leakproof construction . . . strong key-type locking of body between tubing and heads . . . compact, space-saving design. Everything you need in a cylinder . . . *plus special delivery to you*. Get in touch with us *today* for what you need *tomorrow!*

PHONE SERVICE 24 HOURS A DAY!
Order day or night. For fast service call CARTER: LANSING, ILLINOIS, GRanite 4-3305 or CHICAGO, BAyport 1-7186. TELETYPE LNSG, ILL 1119X.

COMPLETE CATALOG FILE!
Complete bound file with ordering details for: Air Cylinders; 750 lb. Hydraulic; 1500 lb. Hydraulic; Clamp Cylinders; Air Valves; Built-in Valve Types. Complete with parts data, specifications and prices. Send today!

CARTER CONTROLS INCORPORATED
2914 Bernice Road • Lansing, Illinois (Chicago Suburb)
AIR CYLINDERS • AIR VALVES • HYDRAULIC CYLINDERS
ROTARY ACTUATORS • SPECIAL CONTROLS

Circle 423 on page 19

Central Foundry Division's
atomic camera
speeds the development and production of railroad journal bearing frame adaptor

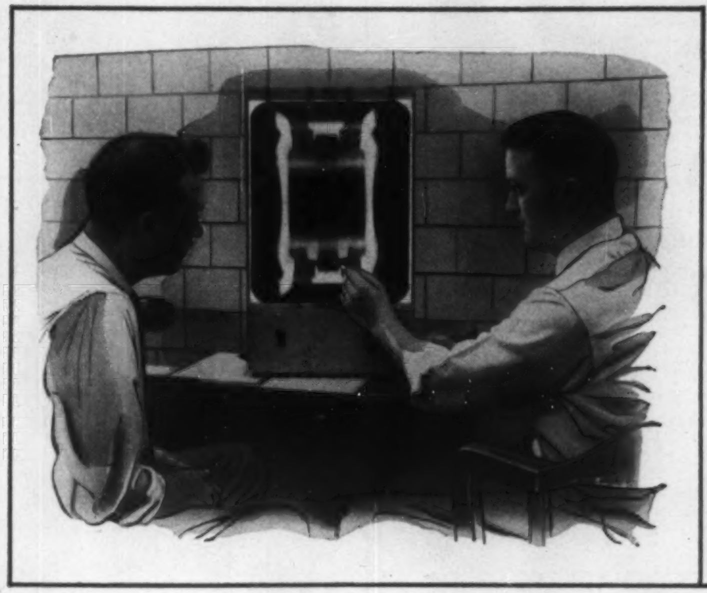
In experimental or new castings, time is an all-important factor. The problem is not only to get them as soon as possible but to get them *perfect.*

Central Foundry Division is now solving this by employing an Atomic Camera of the 30-Curie, Cobalt 60 type, which produces an "X-ray" picture of the casting's internal structure.

Analyzed by trained personnel, radiographs quickly and accurately reveal casting defects, and indicate where modifications must be made. They also point out where foundry gating technique can be improved to lower casting cost.

A typical instance in which Central Foundry's Cobalt 60 inspection process proved its value is on this 66-pound railroad bearing frame-adaptor casting (shown above).

In the same manner as in making medical X-rays, a film is secured behind the casting to be radiographed and the casting is then placed in front of the Cobalt 60 camera. As a safety measure, the radioactive pellet is positioned for the exposure by remote control from a radiation-proof room. The resulting radiographs show the entire internal structure of the casting.

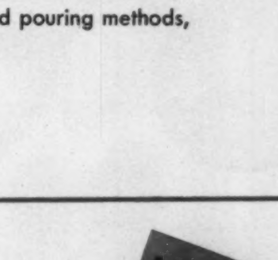


Here trained specialists at Central Foundry Division analyze the radiograph. In the case of the railroad bearing frame-adaptor, radiography indicated that the number of gates could be reduced from 2 to 1 thus reducing costs. The resulting castings were sound (completely free from porosity). The fabricator will now be able to have quality castings, for experimental work as well as in production quantities.

The usual practice in checking for internal defects in a malleable or pearlitic malleable (ArmaSteel) casting consists of breaking up the casting in its white (unannealed) state, then double checking by later cutting an annealed casting . . . pieces of which are etched in acid. Besides the destruction of castings, this system is imperfect because there is no guarantee that the casting will be cut in an unsound area; should one exist. With Central Foundry's Cobalt 60 testing, there is NO PART OF THE INTERNAL STRUCTURE HIDDEN from careful scrutiny. In addition, the Atomic Camera can do a much better testing job in an hour than can be done in days by the usual methods.

The Atomic Camera at Central Foundry helps insure that new or experimental castings are sound. And it points the way to making alterations in gating and pouring methods, and can even show how to improve the design of the casting itself.

If you are interested in getting sound experimental as well as production castings —faster; eliminating the headaches of trial-and-error testing and disappointing results in the field, arrange for a consultation with our engineers . . . or write for the two new books, "Central Foundry Shell Castings", and "ArmaSteel".



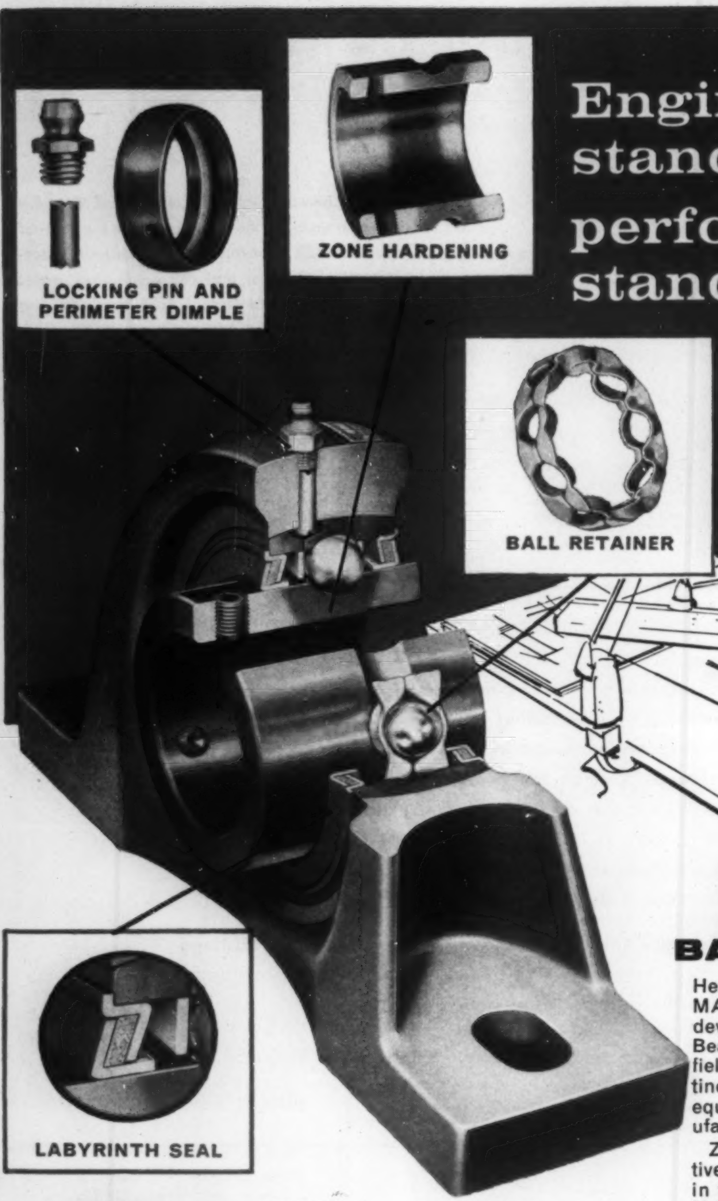
77

CENTRAL FOUNDRY DIVISION

GENERAL MOTORS CORPORATION • SAGINAW, MICHIGAN • DEPT. 14

Circle 424 on page 19

Engineering that stands out... performance that stands up!



SEALMASTER®

BALL BEARING UNITS

Here in the engineering department of SEALMASTER, many advanced features have been developed that have made SEALMASTER Ball Bearing Units the quality leader in the bearing field. These features not only provide a distinct advantage for SEALMASTER, they offer equal benefits for the original equipment manufacturers we serve.

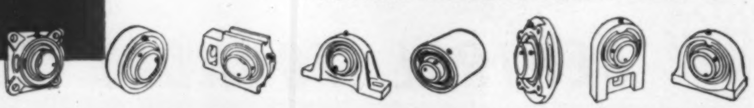
Zone Hardening for example, means positive race to shaft holding power, a vital feature in today's high speed machinery. SEALMASTER'S land ridden ball retainer assures accurate spacing of balls, eliminating ball wear while equally distributing radial and thrust loads. A labyrinth seal consisting of felt-lined steel flingers rotating in labyrinth prevents entry of dust and dirt and retains proper amount of lubricant. SEALMASTER'S patented locking pin and perimeter dimple prevents rotation of outer race assuring positive lubrication while allowing for several degrees of misalignment.

Whether you design air conditioning equipment or road machinery; textile machines or farm equipment you'll want full information on these and other SEALMASTER features.

Write for Bulletin 454 for full information

SEALMASTER®

BALL BEARING UNITS



SEALMASTER BEARINGS A DIVISION OF STEPHENS-ADAMSON MFG. CO. 18 RIDGEWAY AVENUE, AURORA, ILL

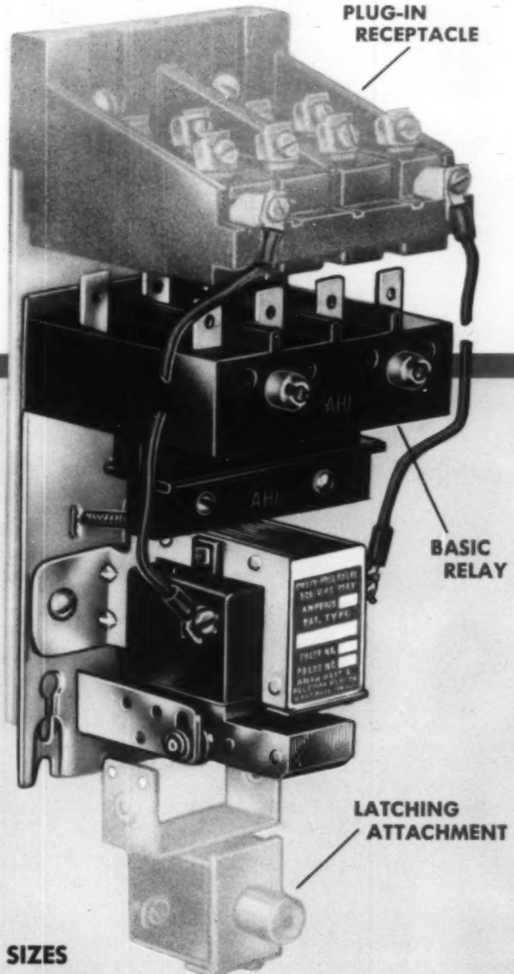
Circle 425 on page 19

Circle 426 on page 19→

Announcing
THE COMPLETE MACHINE TOOL RELAY

by **ARROW AH HART**

A NEWER, FINER ADVANCED-DESIGN COMPONENT THAT DOES MORE DIFFERENT TYPES OF JOBS . . . *BETTER!*



SIZES
0 and 00–
600 V AC

Check these features for

✓ **ADAPTABILITY —**

- **CONTACTS QUICKLY CONVERTIBLE** . . . from normally-open to normally-closed, no tools needed. No loose parts. Exclusive center positioning device guards against contact damage while converting.
- **OPTIONAL LATCHING ATTACHMENT** . . . *another A-H exclusive,* allows quick conversion of contactor to latching type. This attachment is quickly changed from **latch-in** to **latch-out** operation or **latched-in and out.**
- **PLUG-IN/SCREW-TYPE TERMINALS** . . . can be used for plug-in and screw-type as desired.
- **MOST COMPLETE LINE AVAILABLE** . . . Removal of Terminal Screws from Standard Relays converts use to plug-in relays. In 2, 3, 4, 6 or 8 poles . . . in IMP (Interchangable Pole) or FMP (Fixed Pole) types. The **BASIC RELAY** is suitable for use by itself.

✓ **FAST, EASY INSTALLATION and SIMPLE MAINTENANCE —**

- **OPTIONAL PLUG-IN RECEPTACLE** . . . minimizes down-time on high-output machines, since entire contactor unit can be replaced in minutes without disturbing wiring.
- **EXCLUSIVE FRONTAL SWING-OUT** . . . permits fast, easy removal of entire coil.
- **EXPOSABLE MAGNET POLE FACES** . . . for inspection or cleaning.
- **SELF-CONTAINED CONTACT CAGE** . . . with no loose springs, screws or other parts to get lost.
- **MORE COMPACT SIZE** . . . allows easy location, leaves more space for easier wiring.
- **SEPARATE TERMINALS for CONTROL CIRCUITS AND COILS** . . . without using extra poles.

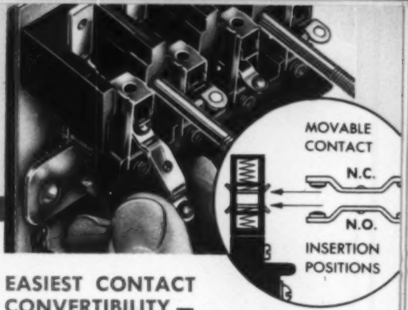
✓ **EFFICIENT, DEPENDABLE OPERATION —**

- **ALL CURRENT-CARRYING PARTS SILVER PLATED** . . . for highest capacity and minimum heating.
- **FRICTION-FREE, DUST-RESISTANT OPERATING MECHANISM** . . . with positive, fail-safe action.
- **ABSOLUTE ALIGNMENT OF PLUG-IN PRONGS** . . . insured by combined receptacle and mounting plate.
- **CONTACTS and GUIDING FRAMES** . . . of special heat-tempered materials to minimize wear and assure smooth action.
- **HIGH-EFFICIENCY SOLENOID MAGNET and MOLDED, LOW-WATTAGE COILS.**

PLEASE TURN THE PAGE FOR ADDITIONAL INFORMATION ➤

Greatest Versatility

ever offered in a SINGLE RELAY DESIGN!



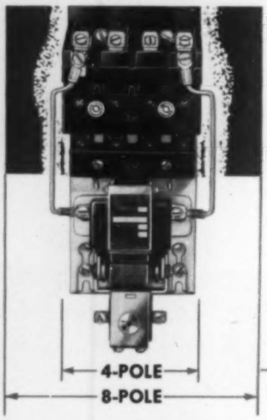
EASIEST CONTACT CONVERTIBILITY —
No tools needed — No loose parts to get lost.

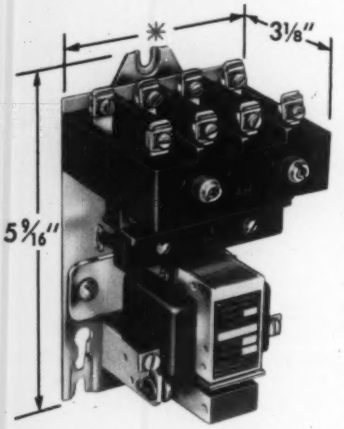
Available

- in AC and DC types
- with 2, 3, 4, 6 or 8 poles
- SIZE 00 (10 Amp) or SIZE 0 (15 Amp)
- IMP (Convertible and Renewable) Type or FMP (Fixed and Renewable) Type
- with Optional Plug-In Receptacle— Type IMP-100 Series
- with Optional Latching Attachment — Cat. #IMP-11 (Specify Coil Voltage)

COMPARATIVE WIDTHS

4-POLE and 8-POLE RELAY with OPTIONAL PLUG-IN RECEPTACLE and LATCHING ATTACHMENT





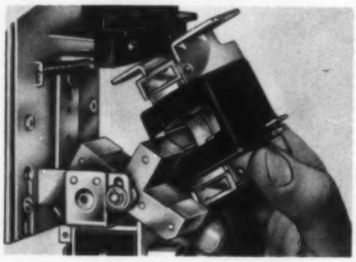
* SEE TABLE

INTERCHANGEABLE MULTI-POLE RELAYS

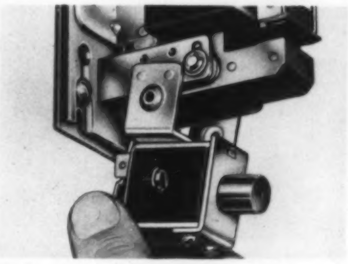
No Other Relay Offers This Versatility In 2, 3, 4, 6 and 8 Poles	Size 00 10 Amp	Size 0 15 Amp	Applicable in Field	Applicable to Standard Relay
Relay—Type IMP CONVERTIBLE and RENEWABLE Contacts	X	X		
Relay—Type FMP FIXED and RENEWABLE Contacts	X	X		
Optional Plug-In Receptacle	One for both		X	X
Optional Latching Attachment	One for both		X	X

No. of Poles	2 to 4	6	8
Width	3"	4½"	6"

Receptacle adds 2¼" to height and ½" to depth. Latch adds 1¼" to height.

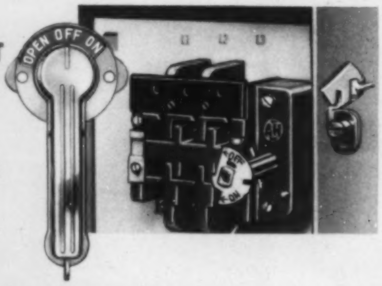


FASTEST COIL ACCESSIBILITY —
Simply remove 2 screws, swing to front and lift out!



HANDIEST LATCHING ATTACHMENT —
Quickly converts any of these contactors to latching type — attachment simply converted in the field — latch-in, latch-out, or latched both ways as desired.

ARROW-HART TYPE "RAD" DOOR DISCONNECTS MEET JIC STANDARDS



the ultimate in —

SAFETY — ALWAYS-VISIBLE CONTACTS give operator constant visual assurance of safety. EASY-TO-SEE HANDLE INDICATORS clearly show "On", "Off", and "Open" positions. SAFE "OFF" FEATURE prevents opening door until handle is purposely turned to "Open" position. LINE COVER prevents accidental contact with live wires.

MINIMUM MAINTENANCE — RUGGED, BUTT-TYPE SILVER CADMIUM OXIDE CONTACTS provide highest possible weld resistance. CONTACTS EASILY REPLACEABLE without disturbing wiring. DISCONNECT HANDLE is oiltight.

EASY INSTALLATION — Both 30 and 60 amp sizes have identical mounting dimensions, making standardization easy. Mounting requires only 3 small holes and 2 screws. Easy-locating feature for hole location. Three adjustable operating shafts take care of variations in panel depth.

THE ARROW-HART & HEGEMAN ELECTRIC COMPANY
103 Hawthorn Street, Hartford 6, Connecticut
MOTOR CONTROL DIVISION
Please send me complete engineering data on:
☐ A-H Type "IMP" and "FMP" Contactors
☐ A-H Type "RAD" Door Disconnects
NAME__________
POSITION__________
COMPANY__________
CO. ADDRESS__________
CITY__________ ZONE ______ STATE ______

ARROW AH HART
Quality since 1890
WIRING DEVICES • MOTOR CONTROLS • ENCLOSED SWITCHES • APPLIANCE SWITCHES

What specifications can't tell you about gasket performance

A resilient gasketing material may meet all pertinent government and industry specifications and still fail to provide a satisfactory seal in actual service. At the same time, a material that falls short of one particular specification may well be the most suitable for a certain application. This points up the fact that while specifications have a definite purpose and value, they are not to be relied on as a guide in selecting gasket materials for a new application.

Specification testing is useful as a means of quality control after a suitable gasket material has been found—making sure that each succeeding shipment has the same physical and chemical characteristics. However, it is impossible to develop tests which will cover all the infinite possible combinations under which a gasket will function.

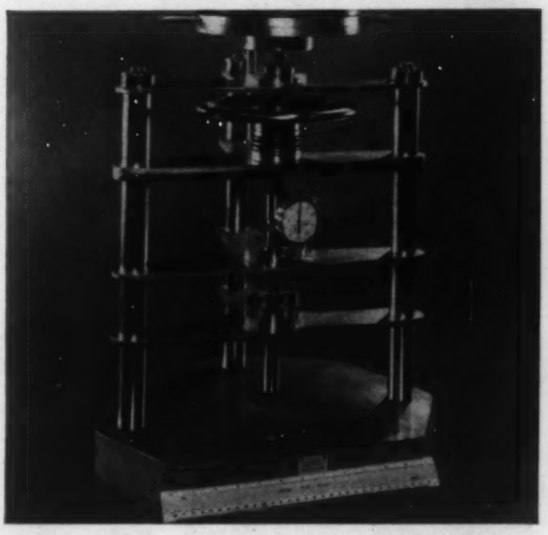
A brief look at some typical tests reveals their shortcomings. For example, many gasket specifications have rigid tensile strength requirements. Tensile strength is easily measured. Yet it usually has no bearing on the sealing ability of a material. Actually a gasket needs only sufficient tensile strength to hold its shape until it goes to work in the flange.

Tests for resistance to liquids are also unrealistic where uncompressed strips of gasket materials are completely immersed in various fluids. Test results may show intolerable changes in such factors as volume, compressibility, recovery, and elongation. In practice, however, only the edge of the gasket is exposed, and the effect of the fluid may be negligible.

This device—called "the spider"—was built at the Armstrong Research and Development Center for use in developing and testing new gasketing materials under varying conditions of flange pressure, internal pressure, and temperature.

Other tests—ream weight and bursting strength for two—have been lifted from the industry that produces the gaskets. Here they have value in helping to maintain quality. But they are of no help to people who use gaskets.

Compounding the difficulties of selection-by-specification is the lack of standardization in test procedures and instruments. In the matter of compressibility alone, there are the variables of sample size, size and type of pressure foot, and the method and speed of load application.



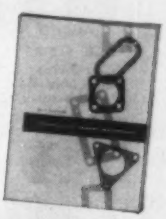
This Armstrong-developed instrument is used to measure indentation and recovery characteristics of resilient gasketing materials. It is recognized by the National Bureau of Standards and is available commercially. Many laboratories now use this device to help standardize gasket testing.

The habit of buying by specification may delay the use of new and improved gasketing materials. Specifications need to be continually examined to see that they describe the materials of today rather than yesterday.

The common question, "Does it meet our specifications?" should be changed to, "Will it do the job better?" Once you can see that a material works better, establishing new specifications to maintain quality is no problem.

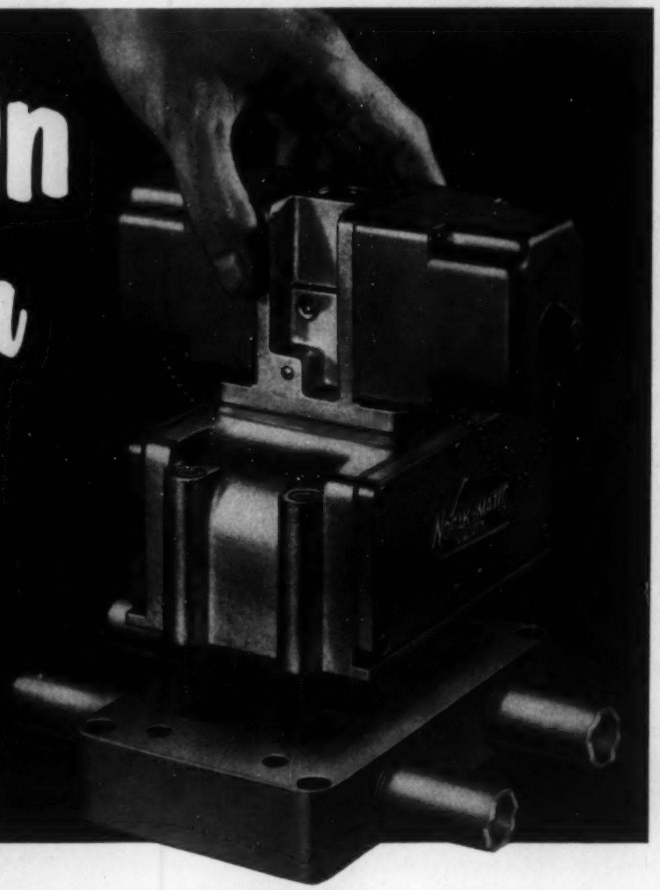
SEND FOR 1957 EDITION OF "ARMSTRONG GASKET MATERIALS"

This 16-page booklet discusses the choice of proper gasket materials and describes Armstrong cork, cork-and-rubber, synthetic rubber, and fiber sheet materials. Look for this booklet in Sweet's product design file. Or for a personal copy, write Armstrong Cork Company, Industrial Division, 7105 Dean Street, Lancaster, Pa.



Armstrong
GASKET MATERIALS
. . . used wherever performance counts

Off 'n On in less than 2 minutes!



Another *Plus Value*

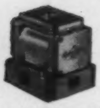
—in *NOPAK-MATIC* poppet-type Air Control Valves

New Nopak-matic valves provide millions of trouble-free operations. But even should maintenance be necessary, it's faster and easier with Nopak-matic. Here's why . . .

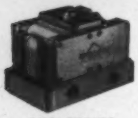
- All models are subplate mounted. To remove a valve from the line takes less than two minutes. Four screws are loosened, the valve removed. Piping is never disturbed.
- Complete in-the-line maintenance can be done in less than fifteen minutes.
- Piston-poppets are contained in easily removable units . . . even seats are quickly replaceable.
- A complete pilot head can be replaced in a few minutes. Any Nopak-matic pilot head (master, single or double solenoid) can be used on any valve.

***NOPAK-MATIC* valves meet *all* J.I.C. Standards**

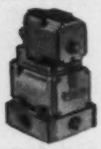
CATALOG 105 describes in detail all the Nopak-matic Plus Values and gives complete installation and parts data. Send for your catalog now and it will be forwarded promptly!



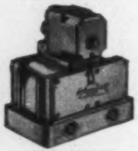
300 SERIES
2-, 3-Way
Master Valves



400 SERIES
4-Way
Master Valves

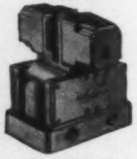


310 SERIES
2-, 3-Way
Single Solenoid
Pilot Operated



410 SERIES
4-Way
Single Solenoid
Pilot Operated

320 SERIES
2-, 3-Way
Double Solenoid
Pilot Operated



420 SERIES
4-Way
Double Solenoid
Pilot Operated

NOPAK

VALVES and CYLINDERS

GALLAND-HENNING NOPAK DIVISION • 2752 South 31st St. • Milwaukee 46, Wis.

A6–602–1P

Circle 428 on page 19

Announcing...... THE WORLD'S FINEST ELECTRIC CLUTCH

One of the best things that designers and users of electric clutches can know about Fawick Magnetic Clutches and Brakes is that they will outperform and outlast existing electric clutches—at no extra cost!

These precision units will establish new clutch performance standards because they are faster in action, more advanced in design, and more adaptable to a wide range of installations.

They are available in sizes ranging from 2 inches to 13 inches in diameter with torque ratings from 22 in-lbs. to 30,000 in-lbs. For detailed information, write the Home Office, Cleveland, Ohio for Bulletin M-101 or contact your nearest Fawick representative.

Representatives in Principal Cities

FAWICK AIRFLEX DIVISION
FAWICK CORPORATION
9919 CLINTON RD. • CLEVELAND 11, OHIO
In Canada, Fawick Canada, LTD., Toronto

FAWICK Magnetic
INDUSTRIAL CLUTCHES AND BRAKES

Circle 429 on page 19

CAPACITY
1 7/8" TO 2 1/4" INCLUSIVE
TH - 1 1/4" OR SHORTER
READS - 11 OR FINER
1 1/2" STANDARD PIPE TAP
CLASS "S"

Universal collapsing tap parts of **MAX-EL** alloy steel finish machined after full heat treatment

Considerable machining is required in the manufacture of parts for these taps. That's why Crucible MAX-EL® 3½ free machining alloy steel was chosen by the Geometric Tool Company, Division of Greenfield Tap and Die Corporation. For with MAX-EL you can rough machine, *then* heat treat even intricate parts before final machining *with no danger of distortion of the steel.*

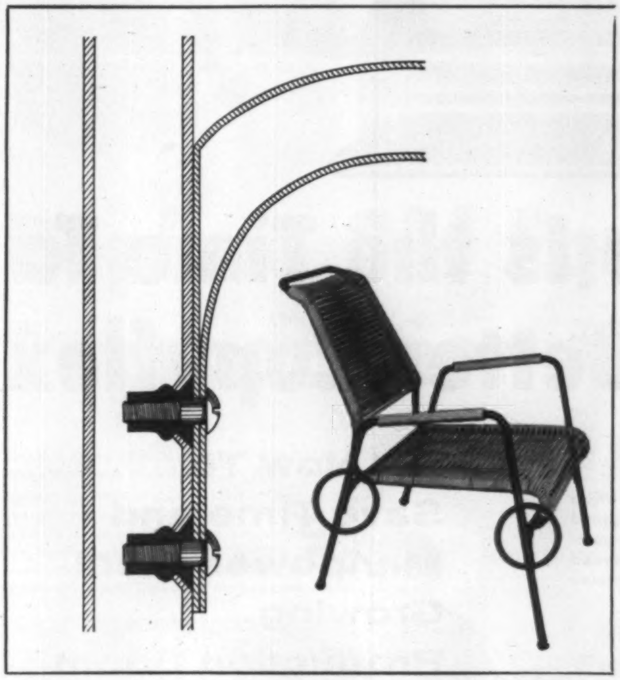
But the best way to check the advantages of MAX-EL is to try it in your own shop. Like many other users you'll appreciate its superior machinability, freedom from distortion, deep hardenability characteristics, uniformity and quality. And you'll like the longer tool life you get by using MAX-EL.

For complete data . . . and *quick delivery* of MAX-EL alloy steels, from local warehouse stocks, call *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

Only B.F. Goodrich Rivnuts® give you firm, blind nutplates for tubular applications!



Finding a fastener that would preserve the clean, functional lines of their modern tubular furniture was a problem for the O. Ames Company. Stove bolts and screws projecting from the legs were not only unsightly, but were a major sales deterrent to a woman in 51 gauge nylons.

B. F. Goodrich Rivnuts provided the answer to this problem. Upset inside the tubular legs, Rivnuts with countersunk heads fit flush, take round headed attachment screws. In addition, Rivnuts hold firmly and permanently because the bulge in the Rivnut shank conforms to the curvature of the tube. Rivnuts are installed by one man in seconds, and provide an accurate nutplate for quick assembly of the finished product.

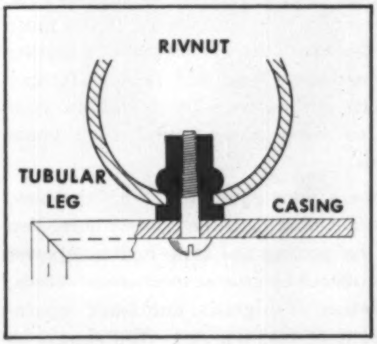
If you want to do a smoother fastening job, or are looking for ways to fasten faster and at less cost, use B. F. Goodrich Rivnuts.

SEND NOW FOR FREE RIVNUT DEMONSTRATOR

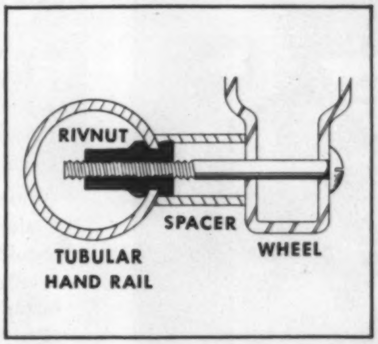
Demonstrates with motion how Rivnuts fasten *to* and *with*. Explains construction, gives proved applications. Write to B. F. Goodrich Rivnuts, Dept. MD-5A, Akron, Ohio.

SEE HOW
RIVNUTS WORK

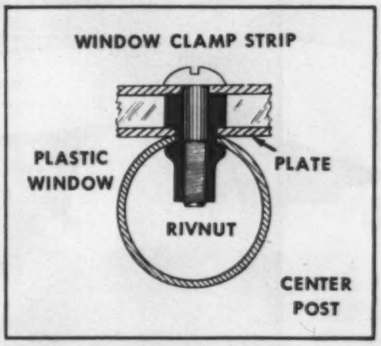
Rivnuts solve a variety of tubular fastening problems like these



Switching to Rivnuts speeded assembly of barbecues. One man installs a Rivnut in the tubular leg in seconds. There are no boltheads to detract from the unit's clean lines. Time is saved in faster knockdown for shipping.



Designers of a wheel chair needed a blind fastener with at least 6 clean threads to serve as a nutplate. Rivnut upset inside the tubular handrail of the wheel chair provides firm, accurate, nutplate for bolt attachment to the wheels.



Upset Rivnut secures airplane window plate to center post. Firm bulge in shank seals weather out. Rivnut head serves as spacer for plastic window, while 6 clean threads hold clamp strip and window securely in place.

B.F.Goodrich

B.F.Goodrich Aviation Products

a division of The B. F. Goodrich Company, Akron, Ohio

Circle 431 on page 19

NOW! A Small Machine That Makes Big Prints . . . New Model 300!

It's only 46" wide, yet offers a full 30" printing width! This remarkable low-priced table top machine brings "inside" reproduction within the means of the smallest department or firm, makes an ideal "extra" machine for large companies. Handles every type of reproduction job that bigger, costlier machines do. Operates on 115 volt A.C.

Right Now Is the Time To New and Better Copyflex

NOW! A Faster, Easier-to-Use, Heavy-Volume Machine . . . New Model 500!

You'll turn out more work with less operator time and effort with this new, ultra-fast machine. It offers top mechanical speed of 40 f.p.m., 46" printing width, automatic separation, front or rear delivery, automatic stacking, and a host of other advanced features. Its 4,000-watt quartz lamp and synchronized exposure and developer units assure uniformly sharp, clear prints.

Act Now To Save Time and Manpower, Meet Growing Production Boom Demands!

Now is the time to take a good look at your older reproduction equipment. If it's more than a few years old, chances are it's costing you unnecessary time and money. It may well turn out to be a bottleneck in your efforts to meet growing production boom demands.

Compare your equipment with the new, modern Bruning machines shown here. You should be getting the time and manpower savings offered by greater mechanical speeds, faster return of originals, automatic separation, front or rear delivery! You should be benefiting by problem-free installation and operation—no exhaust venting, no plumbing or auxiliary equipment, no installation other than an electrical connection.

If you're not getting these important advantages, then every day you delay getting new, modern Copyflex is costing you time and money. Act now by mailing the coupon below. You'll be glad you did!

NOW! The Speedy, Versatile Helper Your Big Machine Needs . . . New Model 110!

When you need prints of such smaller size originals as specification sheets, check prints, and engineering changes, this handy table top machine turns them out in a jiffy without tying up your big machine. It saves you time, money, and inconvenience. It has a printing width of 11". Makes 8½ x 11 prints for less than 1¢ each for materials. Operates on 115 volt A.C.

Replace Old Equipment with Reproduction Machines!

NOW! A Space-Saving, Versatile Big-Volume Machine . . . New Model 250!

It takes less than a square yard of floor space, yet offers a printing width of 18½" and a fast mechanical speed of 25 f.p.m. Automatic separation and stacking, one-knob control, and an extra-large feed board simplify and speed operator's work. Operates on 220 volt A.C.

NOW! A Budget-Priced, Heavy-Volume Machine . . . New Model 35!

This low-cost machine gives you all the advantages of big volume savings and speed. It provides a full 46" printing width and up to 30 f.p.m. mechanical speed. One knob controls exposure and development, assures consistently top quality prints. Handles roll stock up to 42" wide quickly and efficiently. Operates on 220 volt A.C.

SEND FOR MORE INFORMATION TODAY!

BRUNING
Copyflex

Best Process! Best Machines!
Best Selection of Materials!

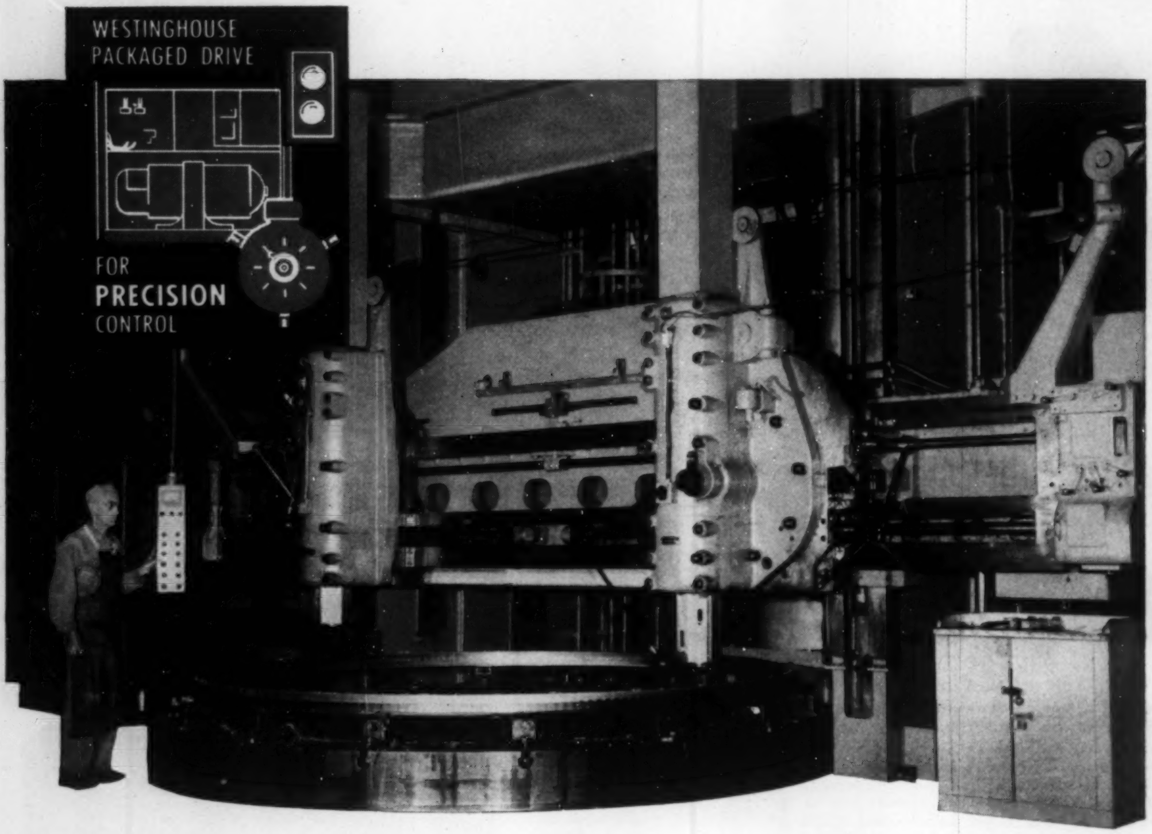
Offices in 37 Cities of the U. S. and Canada

CHARLES BRUNING COMPANY, INC., CHICAGO
In Canada: Charles Bruning Co. (Canada) Ltd., 105 Church St., Toronto 1, Ont.

Charles Bruning Company, Inc., Dept. 53-K
4700 Montrose Ave., Chicago 41, Illinois

Please send me information on the Copyflex process and the following machines: __________

Name__________ **Title**__________
Company__________
Address__________
City__________ **County**_____ **State**_____



"Adjustable-speed Westinghouse AV-DRIVE tripled production on our 14′ boring mill,"

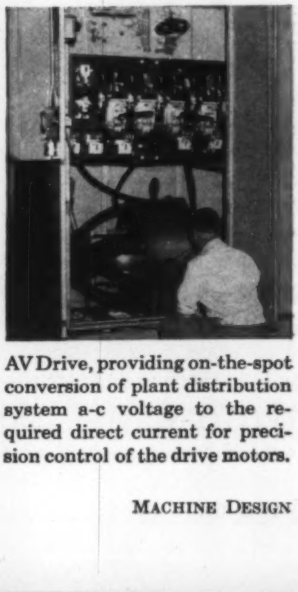
says Chief Engineer, Standard Steel Works Div., Baldwin-Lima-Hamilton Corp., Burnham, Pa.

A twist of the dial at the pendant operator's station controls a speed range of ½ to 22¼ rpm on this vertical boring mill equipped with Westinghouse AV Drive. Precision control of the 75-hp Westinghouse d-c motor produces the work formerly done by *three* belt-driven mills operated by Standard Steel Division.

In addition to the precision and adjustable speed necessary for turning, facing and boring weldless steel rings, the 19 Westinghouse AV Drives now in use give Baldwin-Lima-Hamilton the versatility needed for profitable use of their huge metal-working facilities.

To learn how the versatile Westinghouse AV Drive can make your production more profitable, call your local Westinghouse representative or write Westinghouse Electric Corporation, 3 Gateway Center, P. O. Box 868, Pittsburgh 30, Pennsylvania.

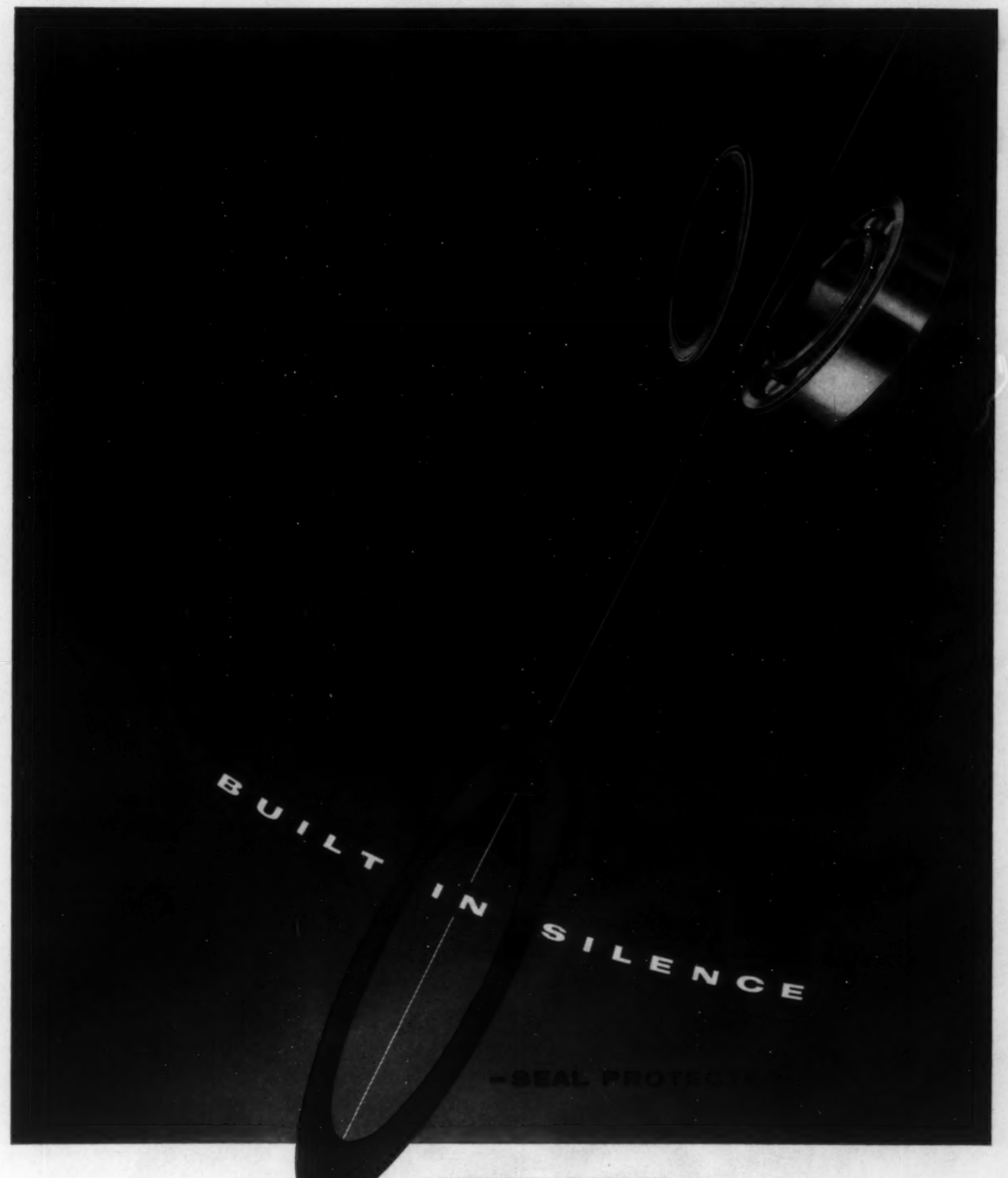
J-22014



AV Drive, providing on-the-spot conversion of plant distribution system a-c voltage to the required direct current for precision control of the drive motors.

YOU CAN BE SURE...IF IT'S Westinghouse

Circle 433 on page 19



EVERY TYPE—EVERY USE

SKF®

- *Ball Bearings*
- *Cylindrical Roller Bearings*
- *Spherical Roller Bearings*
- *Tapered Roller Bearings* (*Tyson*)

7762

*Reg. U.S. Pat. Off. Tyson Bearing Corporation

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

The most silent rolling contact bearing in the world of today

drive gears in BOLENS TRACTORS

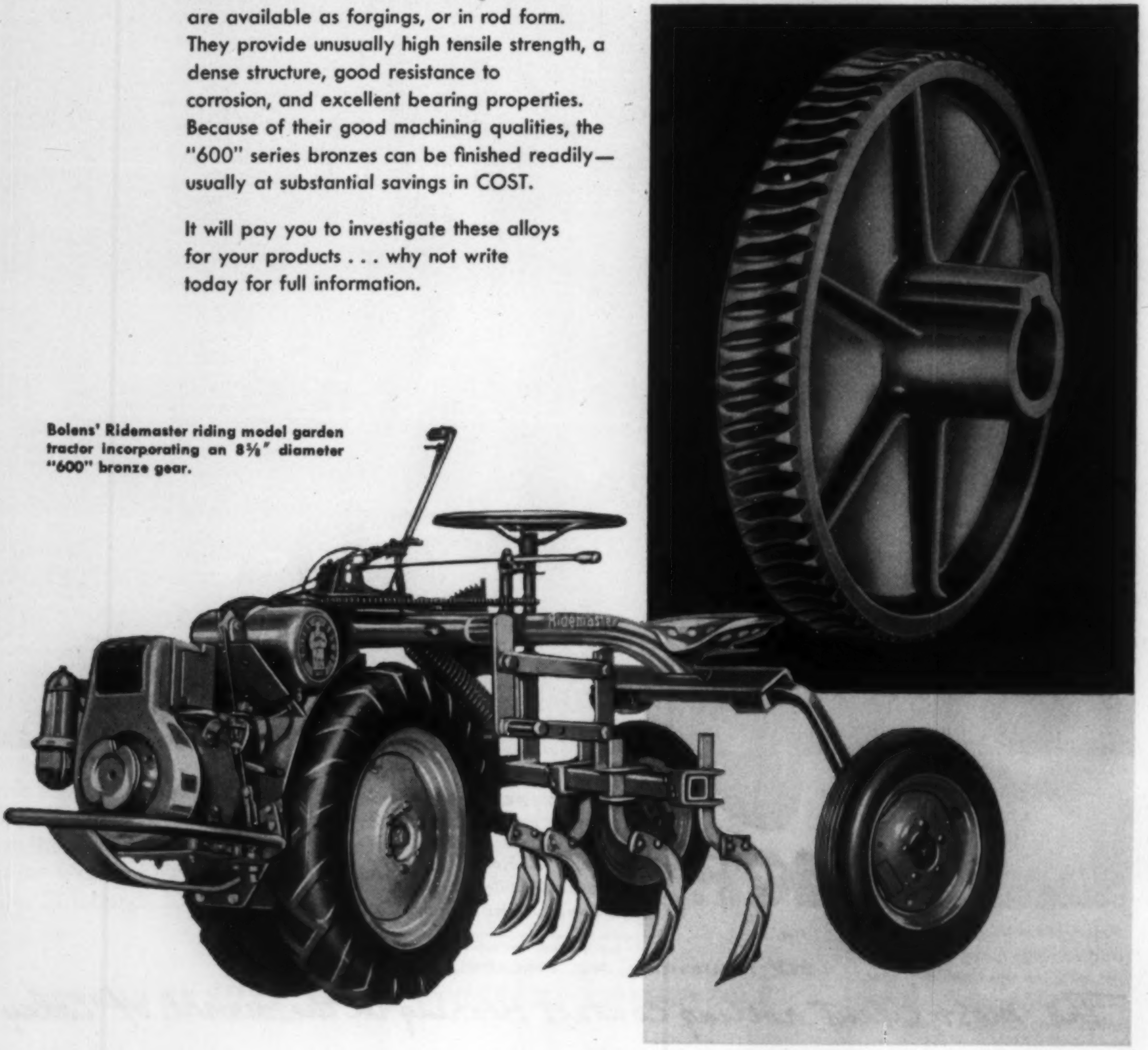
toughness of MUELLER BRASS

"600" series bronze alloys

Forged bronze gears made from tough, long-wearing Mueller Brass Co. "600" bearing alloy are proving their ability to withstand punishment in the popular outdoor power equipment manufactured by the Bolens Products Division of Food Machinery and Chemical Corporation, Port Washington, Wisconsin. The Junior and Super Mustang rotary tillers, all employ "600" main drive gears to dependably transmit engine power to drive assemblies. The going is rough for equipment of this type in cultivating or tilling heavy soil—but Bolens has a record for ruggedness and, on these and many other Bolens products as well,
Mueller Brass Co. "600" gears help make possible that fine performance.

Mueller Brass Co. "600" bearing bronzes are available as forgings, or in rod form. They provide unusually high tensile strength, a dense structure, good resistance to corrosion, and excellent bearing properties. Because of their good machining qualities, the "600" series bronzes can be finished readily—usually at substantial savings in COST.

It will pay you to investigate these alloys for your products . . . why not write today for full information.



Bolens' Ridemaster riding model garden tractor incorporating an 8⅝" diameter "600" bronze gear.

and TILLERS prove

CO.

Bolens' Super Mustang rotary tiller incorporating a 25-tooth "600" series bronze worm gear.

• WRITE TODAY FOR THE ENGINEERING MANUAL YOU NEED

Mueller Brass Co. Forgings Engineering Manual H-58565 ☐

Tuf Stuf Aluminum Bronze Alloys Engineering Manual H-58563 ☐

"600" Series Bearing Alloys Engineering Manual FM-3000 ☐

Copper Base Alloys in Rod Form Engineering Manual FM-3010 ☐

forgings
• brass
• bronze
• aluminum

198

METALS AND ALLOYS REVIEW

by FRANK M. LEVY

Vice-President and Director of Research

One of the most interesting things about our 600 series bearing alloys is the great variety of products in which they find application. In the advertisement to the left you can see how the Bolens people put 600 gears to work in their rotary tillers and garden tractors. Those gears are big, take a lot of abuse, and meet the job needs perfectly. We also make a lot of small parts, too, that have been specified because of the many unusual properties of this series of alloys.

One good example that comes to mind is a shaft bushing on a rotary selector switch that we make for an instrument manufacturer. This selector is used for switching sound-powered telephone circuits aboard Naval vessels. One of the most important considerations in the choice of 600 alloy for this bushing was its resistance to abrasive action on and against a rubber "O" ring. The acceptance test required a stainless steel shaft riding in the bushing to rotate "dry" for a minimum of 50,000 cycles consisting of 360° rotation clockwise followed by a 360° rotation counter-clockwise. The "O" ring must still form a watertight seal at the end of the test. Our 602 alloy was the only one of several materials tested that met the specs. That was pretty good evidence in itself of resistance to abrasion, but, in addition, this customer also found that the use of 602 eliminated the headaches they previously had with seizing and galling.

The pounding action caused by the indexing mechanism attached to the shaft used to give them no end of seizing troubles. The chief product engineer is extremely happy about the way our alloy is performing. Mention was also made of the fact that the corrosion resistance of 602 was mighty impressive. In this application, the alloy passed the 200-hour Navy salt spray test with flying colors.

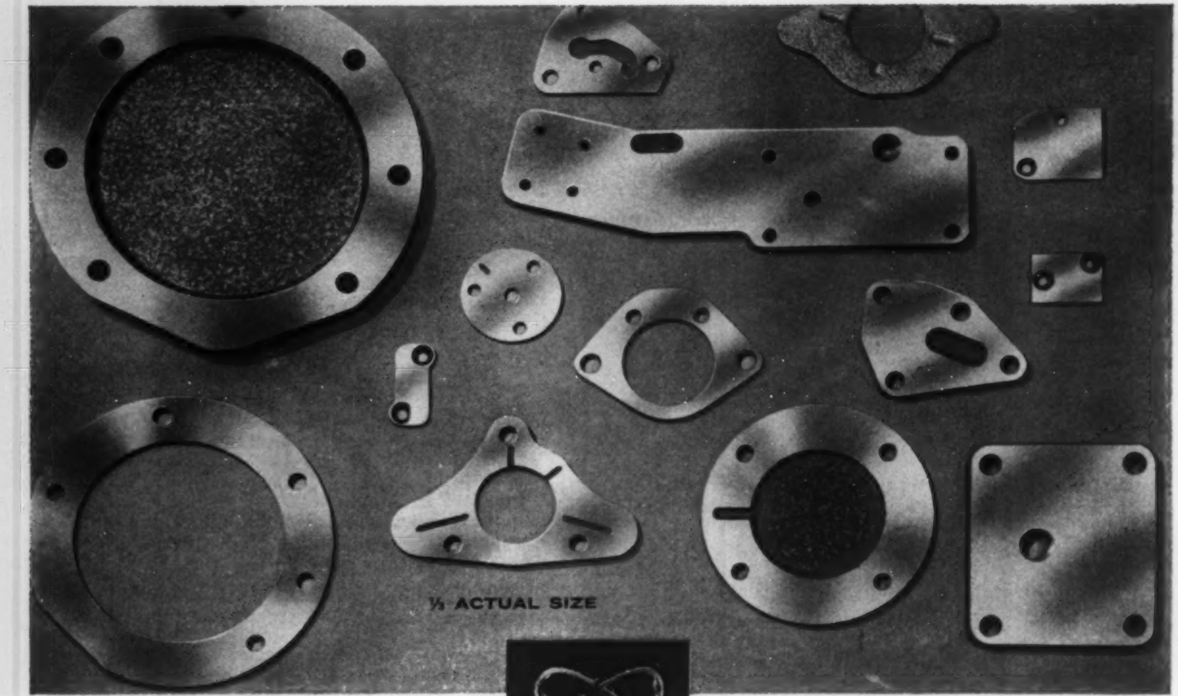
So, big or small, it seems that there is no end of applications for 600 series alloys. We even have parts working in a machine that slices frankfurters as well as gears in fishing reels. So, it seems that 600 runs the gamut from "red hots to reels". Well, it looks like the end of the page is here again, so I'll close for now. However, if you have any problems or questions about non-ferrous alloys or you're having trouble getting desired performance from a part, why not drop me a line here in Port Huron, and possibly I can be of some service. Send a part print along if you like, and we'll be glad to make proper recommendations.

Thanks again for your time.

MUELLER BRASS CO.

PORT HURON 20, MICHIGAN

Circle 435 on page 19



From the product of piston rings used in 1 out of every 3 new cars . . .

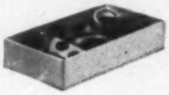
Precision castings-machined and finished-all at "captive cost"

The world's largest piston ring foundry—Muskegon's Sparta Foundry—is now producing precision castings at surprisingly low cost!

Example: Sparta can give you width tolerances to within .001"; surface finishes and flatness to your specifications. With Sparta precision castings, your finishing and machining operations can be reduced or completely eliminated. The result: lower unit costs, improved design, less machining and assembly time.

WRITE FOR YOUR FREE SAMPLE KIT

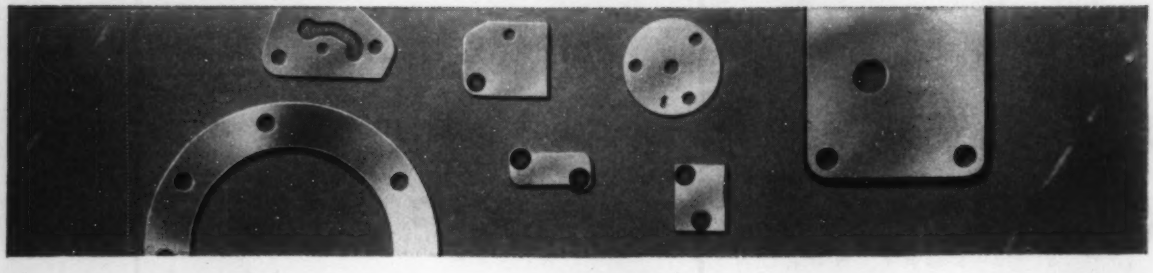
You'll get an assortment of miniature castings in varying degrees of finishing and machining —in a variety of metals, including sintered powdered metals. See how cast-in holes, recesses and projections can eliminate costly machine work. Sparta Foundry Co., Sparta, Mich.



MUSKEGON
Piston Ring Co.

Since 1921... The engine builders' source!

PLANTS AT
MUSKEGON, MICHIGAN
SPARTA, MICHIGAN
ROTARY SEAL DIVISION
PLANTS AT
SPARTA, MICHIGAN
CHICAGO, ILLINOIS



STAINLESS STEEL MAKES THE DIFFERENCE

...its effect on modern equipment

Sanitation ... easy maintenance ... inherent cleanliness ... ready adaptability to a host of different shapes and forms—these are a few of the reasons why more and more designers of food processing, dairy and beverage equipment specify stainless steel.

You'll find it in tubing, tanks, bulk coolers, autoclaves and dozens of other vital pieces of equipment in many different industries.

Stainless steel's superior resistance to corrosion ... ready availability in scores of work-saving standard shapes adaptable to many needs ... ease of machining, forming, joining and casting combine to give equipment producers greater freedom of design.

For more information about stainless steel and its growing effect on equipment design and selling problems, see your stainless steel supplier or write ELECTROMET—leading producer of more than 100 alloys for the metal industries, including chromium and manganese used for making stainless steels.

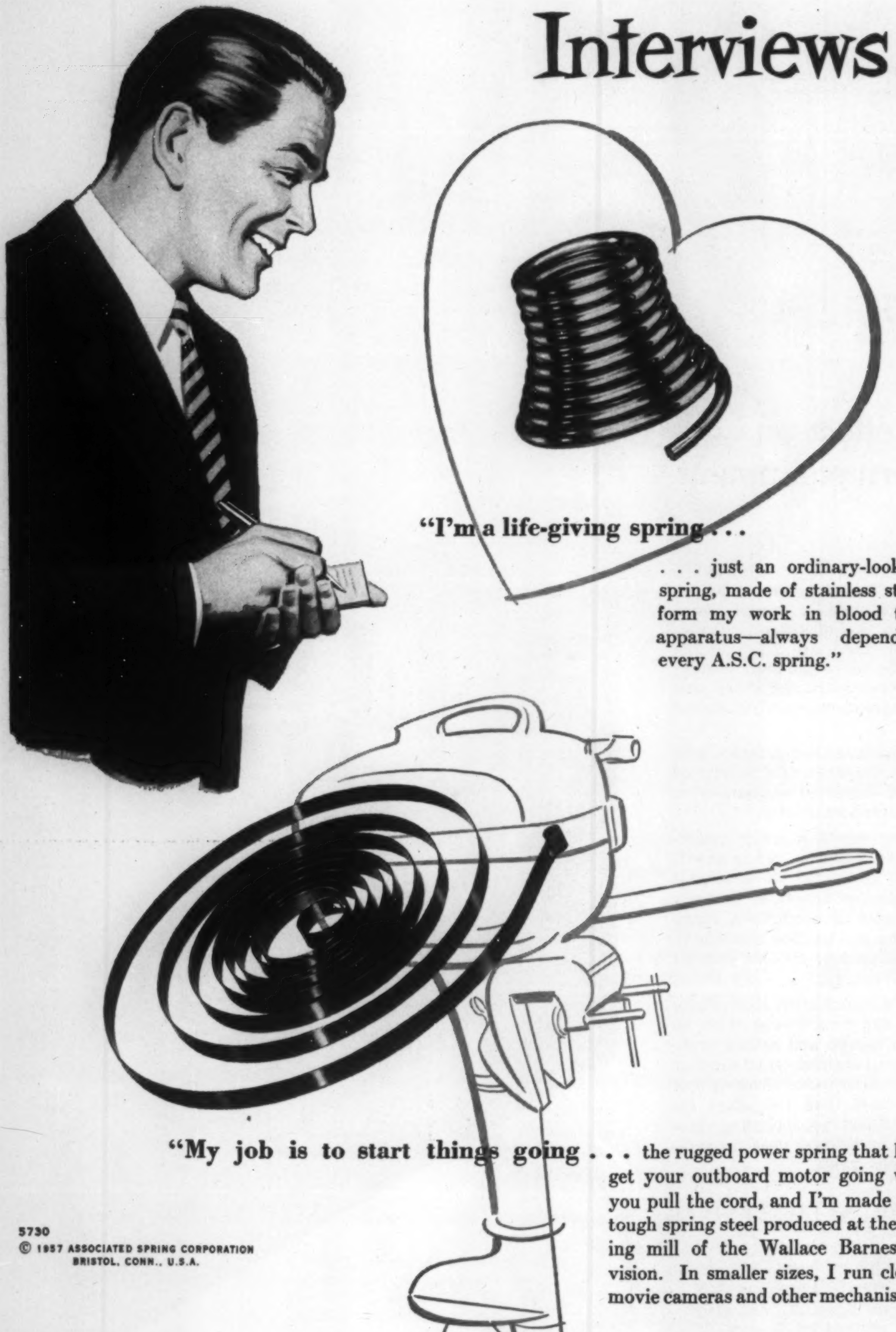
ELECTRO METALLURGICAL COMPANY
A Division of
Union Carbide and Carbon Corporation
30 E. 42nd Street UCC New York 17, N.Y.

METALS DO MORE ALL THE TIME
... THANKS TO ALLOYS

Electromet
TRADE-MARK

Sanitation is a powerful selling tool in the beverage, food processing and dairy fields. That's why the use of sanitary, easy-to-clean stainless steel is growing so fast.

Interviews...



"I'm a life-giving spring . . .

. . . just an ordinary-looking coiled spring, made of stainless steel, I perform my work in blood transfusion apparatus—always dependable—like every A.S.C. spring."

"My job is to start things going . . . the rugged power spring that helps get your outboard motor going when you pull the cord, and I'm made from tough spring steel produced at the rolling mill of the Wallace Barnes Division. In smaller sizes, I run clocks, movie cameras and other mechanisms."

5730

© 1957 ASSOCIATED SPRING CORPORATION
BRISTOL, CONN., U.S.A.

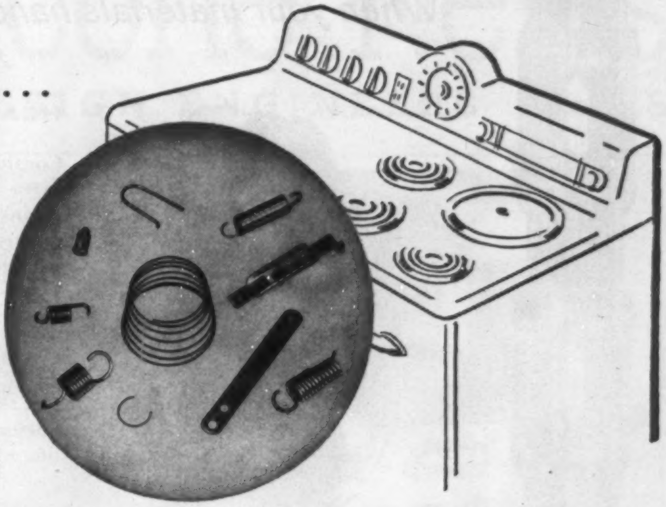
Divisions of

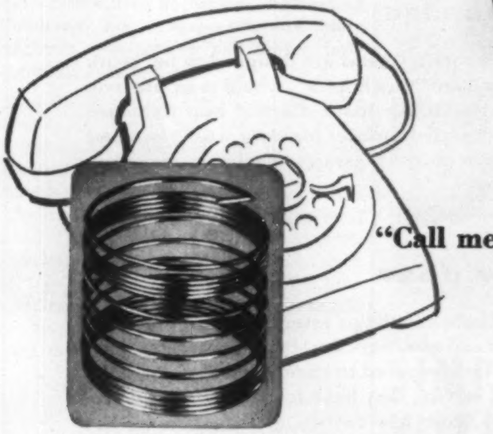
with Successful Springs

"We'll time your eggs . . .

or turn off the current . . .

. . . we're the family of coil and flat springs that control the timing of your electric stove, dishwasher, clothes washer and dryer. Divisions of A.S.C. make all types of instrument springs."

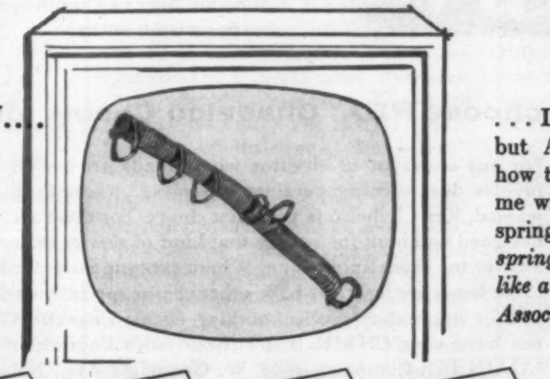




"Call me up sometime . . .

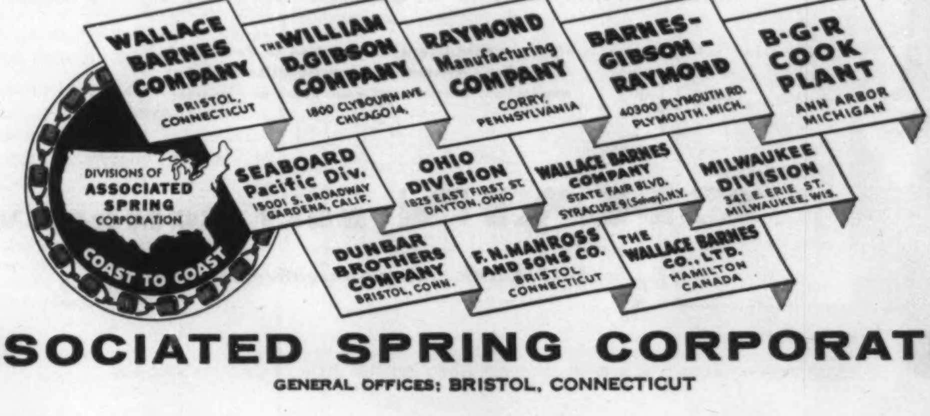
. . . and when your finger dials a Division of Associated Spring Corporation, I'm the spring that returns the dial after each number selection—always at your service."

"Tune me in on T V. . .



. . . I'm not really a spring—but A.S.C. engineers figured how to make tuning coils like me with special coatings on a spring winder. *If you need a spring—or a thing that looks like a spring—see a Division of Associated Spring Corporation."*

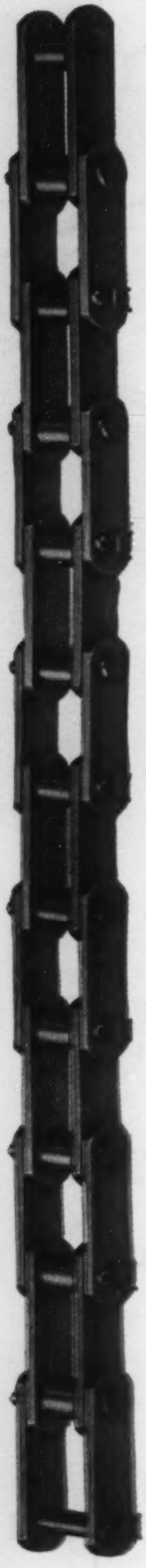
Send for Pamphlet "Designing Springs for Performance"


WALLACE BARNES COMPANY
BRISTOL, CONNECTICUT
THE WILLIAM D.GIBSON COMPANY
1800 CLYBOURN AVE. CHICAGO 14.
RAYMOND Manufacturing COMPANY
CORRY, PENNSYLVANIA
BARNES-GIBSON-RAYMOND
40300 PLYMOUTH RD. PLYMOUTH, MICH.
B-G-R COOK PLANT
ANN ARBOR MICHIGAN
DIVISIONS OF ASSOCIATED SPRING CORPORATION
COAST TO COAST
SEABOARD Pacific Div.
15001 S. BROADWAY GARDENA, CALIF.
OHIO DIVISION
1825 EAST FIRST ST. DAYTON, OHIO
WALLACE BARNES COMPANY
STATE FAIR BLVD. SYRACUSE 9 (Solvay), N.Y.
MILWAUKEE DIVISION
341 E. ERIE ST. MILWAUKEE, WIS.
DUNBAR BROTHERS COMPANY
BRISTOL, CONN.
F. N. MANROSS AND SONS CO.
BRISTOL CONNECTICUT
THE WALLACE BARNES CO., LTD.
HAMILTON CANADA

ASSOCIATED SPRING CORPORATION

GENERAL OFFICES: BRISTOL, CONNECTICUT

Circle 438 on page 19



When your materials handling considerations involve:

HEAVY-DUTY SERVICE

Consider Rex Chabelco Steel Chains. Built-in *extra* strength...*extra* stamina...give these chains exceptionally high working load ratings, the true test of a conveyor chain's ability to perform in heavy-duty applications.

LONG LIFE

Rex Chabelco Chains are designed to be "work horses," not "race horses"...built to assure long life under heavy loads. Careful heat treatment provides hard surfaces for *extra* wear resistance ...inner ductility assures maximum resistance to shocks.

LOW COST

Rex Chabelco Chains assure real economy both in *first* and *operating* costs! Because of their longer pitch, as compared to chains designed for high-speed service, they have fewer parts per foot of chain...cost less to buy and maintain. They operate over cast tooth sprockets, an important economy advantage.

choose REX® Chabelco Chains for lowest cost

For any conveyor or elevator where loads are heavy, operating conditions involve dust, dirt, temperature extremes...where long life and low cost are wanted, Rex Chabelco is your best choice. For these are "work horse" chains, designed and built for exactly that kind of service. Naturally they are not the answer for every application. Where exceptionally precise timing is required ...or loads are light, we have other chains specially designed for these needs. But for heavy-duty service, nothing equals Chabelco Conveyor Chain. Why not have your CHAIN Belt District Sales Engineer show you why! Write CHAIN Belt Company, 4643 W. Greenfield Ave., Milwaukee 1, Wisconsin.

If you would like a subscription to *Rex World*, CHAIN Belt's informative picture magazine of product application, please send your name and address.

CHAIN BELT COMPANY

LEADERSHIP...through creative engineering

Circle 439 on page 19

Circle 440 on page 19→

DOW CORNING CORPORATION

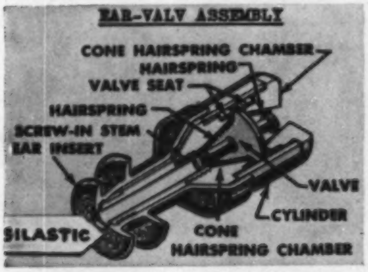
Silicone News

FOR DESIGN ENGINEERS No. 38

IMPROVE "SONIC EAR VALVE" WITH SILASTIC FITTINGS

Because SILASTIC*, the Dow Corning silicone rubber, is exceptionally resistant to sterilization temperatures and to natural body oils, the "sonic ear valve" developed by Sigma Engineering Company, Los Angeles, is now more hygienic, comfortable and longer lasting than ever before.

A protective device, the Sigma ear valve permits the user to hear ordinary conversation while minimizing the ear-splitting effect of loud noises. A complex yet durable unit, the valve consists of a tiny cylindrical mechanism containing several integral parts designed to function either individually or collectively. While each of the parts affords hearing protection, together they provide the utmost protection by dissipating the energy component of noise before it damages the eardrum.



Valve channels made from natural gum rubber were originally used, but the organic rubber had a relatively short service life and could not be sterilized. Sigma changed to SILASTIC fittings when tests proved the silicone rubber channels remain soft and comfortable for at least a year, and are easily sterilized in boiling water without reducing service life.

Sigma sells several thousand units monthly to Ordnance and Air Force personnel, industrial workers and to other occupational groups frequently exposed to loud noises. *T. M. REG. U. S. PAT. OFF. *No. 386*

Dow Corning Silicone Lubricants, including oils and greases, are described in a new, illustrated 8-page brochure that gives their properties, lists typical applications, and cites factors which contribute to obtaining longer life.

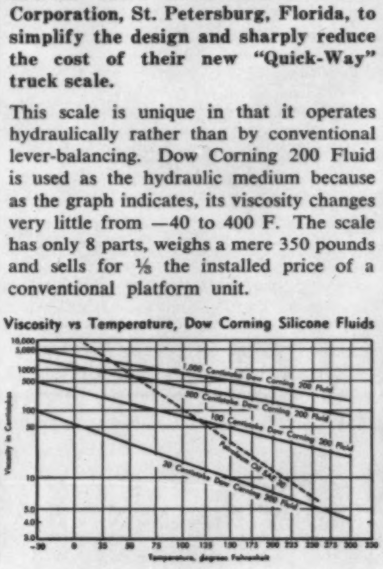
CENTRAL
TRUCK LINES

SIMPLIFY DESIGN, REDUCE COSTS WITH SILICONE DAMPING FLUID

Practical application of Dow Corning 200 Fluid in a hydraulic system has enabled Truck Scale and Research Corporation, St. Petersburg, Florida, to simplify the design and sharply reduce the cost of their new "Quick-Way" truck scale.

This scale is unique in that it operates hydraulically rather than by conventional lever-balancing. Dow Corning 200 Fluid is used as the hydraulic medium because as the graph indicates, its viscosity changes very little from —40 to 400 F. The scale has only 8 parts, weighs a mere 350 pounds and sells for ⅛ the installed price of a conventional platform unit.

Viscosity vs Temperature, Dow Corning Silicone Fluids



The Quick-Way registers axle loads up to 30,000 pounds. Even with a slowly moving load it gives accurate, instantaneous readings on a dial which can be located as much as 50 feet from the scale.

Since Dow Corning 200 Fluid assures accurate readings during extremely hot and cold weather, no extra devices are required to compensate for temperature changes.

Exceptionally resistant to oxidation, the silicone fluid is sealed-in to assure long, reliable service life. About 30 cubic inches of 200 Fluid are used per scale. *No. 387*

For the latest news of silicones and to learn how silicones can help solve your design problems, be sure to visit BOOTH 406 at the Design Engineering Show.

1957
Design Engineering Show
New York
Coliseum
May 20 to 23

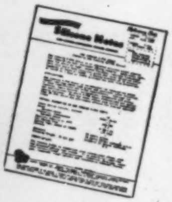
FOR DATA RELATING TO THESE ARTICLES, CIRCLE REFERENCE NUMBER IN COUPON ON NEXT PAGE

MORE ☛

DOW CORNING CORPORATION

Silicone News

DOW CORNING PUBLICATIONS ON NEW DEVELOPMENTS AND TECHNICAL DATA . . . .



New Reference to Silicone Fluids describes the Dow Corning silicone fluids specified for most industrial and military applications. This convenient four-page reference lists typical applications, and physical and electrical properties for each fluid — from flash point to volume resistivity. A useful and compact data source designed to help you select the silicone fluid most suitable for any specific application. *No. 390*

◆

Antifoam B, the lowest priced silicone foamkiller, has greater stability than any other water dilutable silicone defoamer commercially available. Antifoam B will not separate, oil out, settle or precipitate in most applications; retains uniformity and effectiveness even under adverse storage or operating conditions. Ready to use, it requires no diluting or pre-mixing. *No. 391*

◆

Low Pressure Laminating with Silicone Resins is a concise "how-to-do-it" manual that describes methods of making structural and electrical laminates for high temperature service. Also includes after-curing schedules. *No. 392*

◆

"The Effect of High Temperature on the Properties of Organic and Silicone Rubbers," reprinted from RUBBER AGE, contrasts the effects of heat and heat aging on ten types of rubbers, gives a good indication of their respective serviceability at various temperatures. *No. 393*

◆

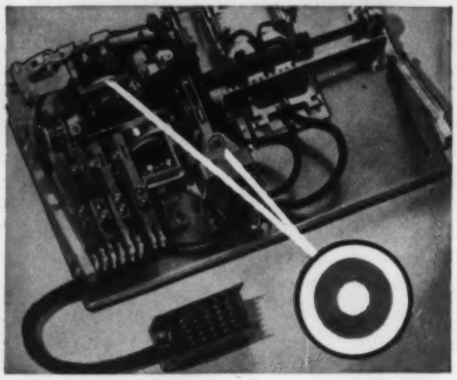
Parts and components made with Dow Corning Silicone Molding Compounds are lightweight, show excellent resistance to heat, and have good structural and electrical properties. Used as brush holders, collector rings, terminal boards, multiple lead connectors, heat dams for turbine driven alternator bearings, and aircraft brake shoe backing. *No. 394*

◆

1957 Guide to Dow Corning Silicones is a twelve page, fact-filled reference describing the silicone products of interest to most industries. Containing latest data and information, the new 1957 Guide is designed expressly to help you enjoy the advantages, profits, and savings made possible through imaginative use of these versatile engineering materials. *No. 395*

SILICONE-GLASS LAMINATES—NEW SOLUTION TO HIGH TEMPERATURE INSULATING PROBLEMS

Faced with a need for electrical or electronic insulating parts that retain high physical and dielectric properties at elevated temperatures, more and more designers are specifying laminated glass parts bonded with Dow Corning silicone resins. Typical is Stromberg-Carlson's use of silicone-glass laminates for coil spacers and insulators in military field-type telephone switches.



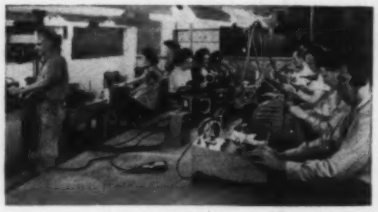
While the cellulose acetate spacers previously employed proved durable enough under normal conditions, they didn't stand up in high temperature use. They failed quickly, for example, when continuing operation with faulty circuits sometimes raised coil temperatures to 320 C (680 F).

Stromberg-Carlson solved the problem once and for all by replacing the acetate spacers with single-ply silicone-glass laminates supplied by Mica Insulator Company.

According to Stromberg-Carlson engineers, the use of silicone bonded glass laminates has "increased the service life and dependability of the telephone switch." *No. 388*

Blind Workers Build Silicone Insulated Canned Motor-Pumps

While many manufacturers are making imaginative use of Dow Corning Silicones to improve product performance, other progressive companies are also using these versatile materials to simplify design and assembly. A striking example of this trend is provided by Nuclear Pump, Inc.



Nuclear has licensed the Philadelphia branch of the Pennsylvania Institute for the Blind to build silicone insulated canned motor-pumps ranging in capacity from 40 to 310 gpm. In addition to assembling the pumps, the blind workers also build the ⅓ to 10 hp silicone insulated motors which power the units.

The motor production and assembly operations performed by these workers include uncrating, weighing, stacking, riveting and grinding laminations, cutting and inserting slot insulation, winding and inserting coils, insulating top sticks, wrapping, connecting, dipping and baking.

The finished units, used primarily in the chemical and food industries, have only one moving part and can be disassembled in two minutes with a screw driver. An exceptionally low rejection rate highlights the fact that handicapped people are very capable workers, and proves again that electrical insulating components made with Dow Corning Silicones are easy to handle.

The reliability of the motors proves that silicone insulation is the most dependable motor protection money can buy. *No. 389*

Dow Corning Corporation, Dept. 6817, Midland, Michigan

Please send me: 386 387 388 389 390 391 392 393 394 395

NAME ____________

TITLE ____________

COMPANY ____________

STREET ____________

CITY ____________ ZONE ____ STATE ____________

SILICONE NEWS is published for product design and development engineers by

first in silicones

DOW CORNING SILICONES

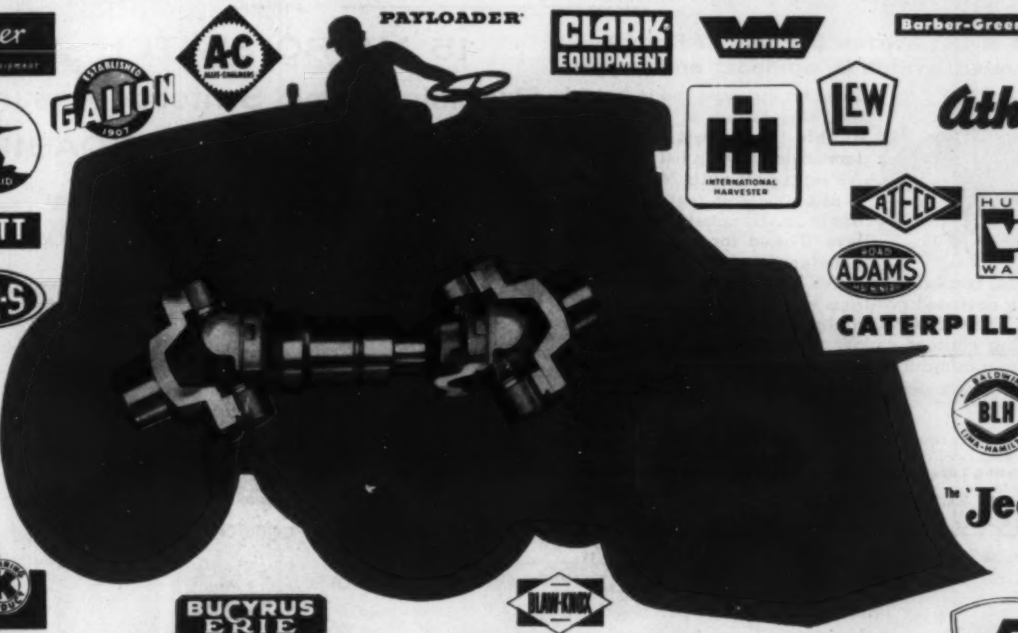
DOW CORNING CORPORATION
MIDLAND MICHIGAN

ATLANTA BOSTON CHICAGO CLEVELAND DALLAS DETROIT LOS ANGELES NEW YORK WASHINGTON, D. C.
CANADA: DOW CORNING SILICONES LTD., TORONTO GREAT BRITAIN: MIDLAND SILICONES LTD., LONDON FRANCE: ST. GOBAIN, PARIS

VERSATILE

MECHANICS Roller Bearing UNIVERSAL JOINTS excell for both main drives and controls — in all kinds of material handling trucks. Have transmission flanges for any type of brake drum. Easy to service —

MECHANICS Close-Coupled UNIVERSAL JOINTS transmit more power — in less space — at greater angles than any other joints. Let MECHANICS engineers help give your machines competitive advantages.



Baker
handling equipment
PAYLOADER
CLARK EQUIPMENT
WHITING
Barber-Greene
A-C
GALION
ESTABLISHED 1907
EUCLID
INTERNATIONAL HARVESTER
LEW
Athey
DROTT
ATECO
HUBER WARCO
ADAMS
M-R-S
CATERPILLAR
fmc
BALDWIN BLH LIMA-HAMILTON
The Jeep
PARSONS
BUCYRUS ERIE
BLAW-KNOX
LeT W
Buckeye
Cedarapids
EIMCO
WOOLDRIDGE
AUSTIN-WESTERN WORKS

MECHANICS UNIVERSAL JOINT DIVISION
Borg-Warner • 2032 Harrison Ave., Rockford, Ill.
Export Sales: Borg-Warner International
79 E. Adams, Chicago 3, Illinois

MECHANICS
Roller Bearing
BW
UNIVERSAL JOINTS

For Cars • Trucks • Tractors • Farm Implements • Road Machinery • Aircraft • Tanks • Busses and Industrial Equipment

MICRO SWITCH Precision

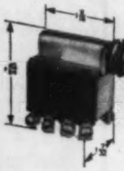
...FIRST IN PRECISION SWITCHING

If reliability, long life, ruggedness, compactness, sensitivity and accurate repeat point of operation are vital to you, then

Look to MICRO SWITCH for a solution of your Precision Switch problems

Here is a partial picture of some of the thousands of switch combinations available—news of a new MICRO SWITCH development—how and for what and why one manufacturer is using MICRO SWITCH Precision Switches—and a report on what MICRO SWITCH field application engineering can mean to alert design engineers

This MICRO SWITCH 3-Position Rotary Actuated Switch is compact and rugged



Ideal for airborne and industrial use, this switch is a four-pole double-throw switch with 12 terminals (catalog listing 4TR1). An eight-pole with 24 terminals is also available (catalog listing 8TR1) . . . Eliminates use of relays. Tested for impact, shock, acceleration and vibration. Careful inspection assures long life operation. Positively detented positions eliminate accidental operation. The solid silver contacts and silver-plated copper moving contact carrier provide maximum conductivity, minimum temperature rise.

(*For more details ask for Data Sheet No. 112*)

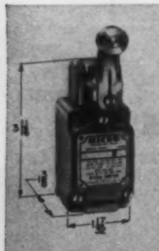
CHARACTERISTICS

Operating Torque (4TR1) . . 9 in. lbs. max.
Pretravel . . . . 10° each direction
Operating Torque (8TR1) . . 4 in. lbs. min. to 6 in. lbs. max.

ELECTRICAL RATING 4TR1 & 8TR1

Continuous	Resistive Load		Lamp Load		Inductive Load	
	30 v dc	115 v ac	30 v dc	115 v ac	30 v dc	115 v ac
20	20	20	5	4	12	15

This Compact Limit Switch Is Widely Used by Industry



This is a double-pole two-circuit switch, completely sealed. Cover screws are held captive in cover when it is removed. The ½ n.p.t. internally tapped opening is in the bottom of the enclosure . . . Actuator can be positively locked in any position through 360° and can be operated in either direction. Actuator head is removable in field, can be rotated to any of four positions. This switch can be mounted either front or back side, .192-inch diameter holes extend through the enclosure, tapped from the back to a depth of 9/16-inch with ¼-20 nc thread. Mounting holes accept No. 10 screws. No. 8 terminal screws accommodate No. 14 stranded wire. Can be used single-pole double-throw.

(*Ask for Catalog 101*)

CHARACTERISTICS

Operating force—3 lbs. max.	Pretravel—20° max.
Full overtravel force—6 lbs. max.	Diff. travel—12° max.
Release force—½ lb. min.	Overtravel—30° min.

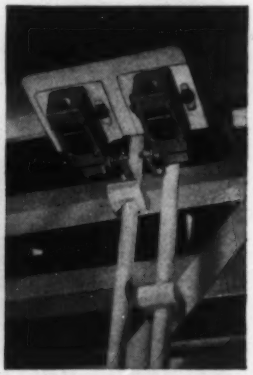
Rated: 10 amps. 120, 240, 480 v ac; ½ H.P. 120 v ac; 1 H.P. 240 v ac; .8 amp. 115 v dc; .4 amp. 230vdc; .1 amp. 550 v dc. Pilot duty rating 600 v ac. max.

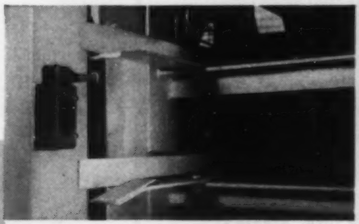
15 MICRO SWITCH Precision Limit Switches Assure ABSOLUTE DEPENDABILITY in Particle Board Loader and Unloader Unit*

Operates 20,000 cycles per day on a 24-hour basis

•

Prevents shut-down time at estimated cost of $50.00 to $100.00 per minute





Three of the many MICRO SWITCH Type "ML" 2-circuit switches index the cage stops of the upward and downward travel of the racks of the particle board loader and unloader unit.

Operating 20,000 cycles a day, these rugged MICRO SWITCH "ML" Limit Switches with their long life, accurate repeatability of point of operation, excellent seal, convenient mounting and one-way actuation features, provide dependability for the continuous high speed production of particle board.

Serving as indicators and timers in various automatic operations, these two-circuit switches control the up and down motion of the unit which loads and unloads the particle board to and from the hot plate press.

The manufacturer* of these custom-built units has standardized on MICRO SWITCH Precision Switches because of their longer life, accurate and dependable operation and excellent environmental seal. As many as 100 switches are used on some of these custom-built units.

(*Ask for Catalog No. 83 "Industrial Enclosed Switches"*)

*Washington Iron Works, Seattle, Washington

Switches have uses unlimited

NEW!

A Subminiature Screwdriver Operated Switch—Saves Wiring and Panel Space

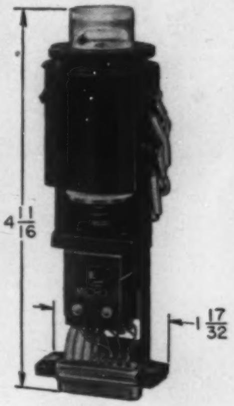
Designed to be used where there is limited access and where accidental operation must be prevented. Switch is operated by a 90° turn of a screwdriver and the slotted head gives visual indication of its position. The switch can be ordered with a number of variations of the subminiature basic switch. Contact arrangement is single-pole double-throw (maintained position).

(To learn full details of this new switch, send for Data Sheet No. 115)

ELECTRICAL RATING

Listed by Underwriters' Laboratories at 5 amps. 125 or 250 v ac. The 30 v dc is: inductive—3 amps. at sea level, 2.5 amps. at 50,000 ft., resistive—4 amps. at both sea level and 50,000 ft. Maximum inrush capacity—20 amps. ac and 24 amps. at 30 v dc.

MICRO SWITCH 3-Light Pushbutton Switch Reduces Panel Space 50%



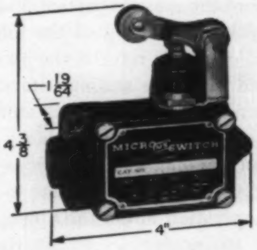
This compact, double-throw double-pole switch with its pre-wired plug will light in three different colors. It was developed expressly for use in complex console panels. Because push button and switch are combined in one unit, it reduces panel space by 50%. The compact stem carries three separate lamps. The switch incorporates a special connector plug which permits quick and easy installation and replacement—no complicated wiring required. Designed for use where high reliability is a requirement; two SPDT precision subminiature basic switches with fine silver or gold contacts and special treated snap-acting springs are the switching elements. All materials are corrosion resistant.

(Data Sheet No. 110 will give you more details. Send for it!)

ELECTRICAL RATINGS

Rated for .1 amp. inductive at 28 or 48 v dc and 1 amp. inductive at 115 v ac.

For Tough Service in Industrial Applications—The "BAF1" High Capacity Series



Especially designed for rough, general service in industrial applications, these MICRO SWITCH Precision Switches are protected from the effects of dirt, dust and occasional liquid splash by an elastomer boot on the plunger and an O-ring gasket under the cover plate . . . This series is really rugged, the three mounting holes in the heavy mounting flange accommodate ¼ in. bolts. These switches have a capacity to make and break steady state currents of 20 amperes and will handle inrush currents as high as 75 amperes. If your service requirements are rugged, this rugged switch will handle them.

(You can learn all about this series, if you send for Catalog No. 83)

CHARACTERISTICS

Operating force	2 lbs.
Release force	1/2 lb. min.
Pretravel	7/32 in. max.
Overtravel	1/4 in. min.
Differential Travel	.015 in. max.

Service Pays Off Again; for Orin McIntyre

"We don't sell switches, we *give* service. Give them the right switch for the job and the switches sell themselves."

That's the sales approach of Orin Mac McIntyre, MICRO SWITCH salesman. And Mac's approach recently paid off.

Mac offered his talents to a prospective customer's engineers, hoping to assist them with their switching problems.

Mac kept at it and finally found the "in." The prospect needed heavy-duty limit switches with extremely light operating force and soft-roller actuators to prevent breakage of his product. Mac checked the home office, found the perfect solution, and had two samples in the hands of the prospect—pronto.

This prospect's engineers found these switches ideal for their needs, and issued an order.

This fast and efficient service made an impression. Soon Mac was called in on another switching problem which resulted in a second order.

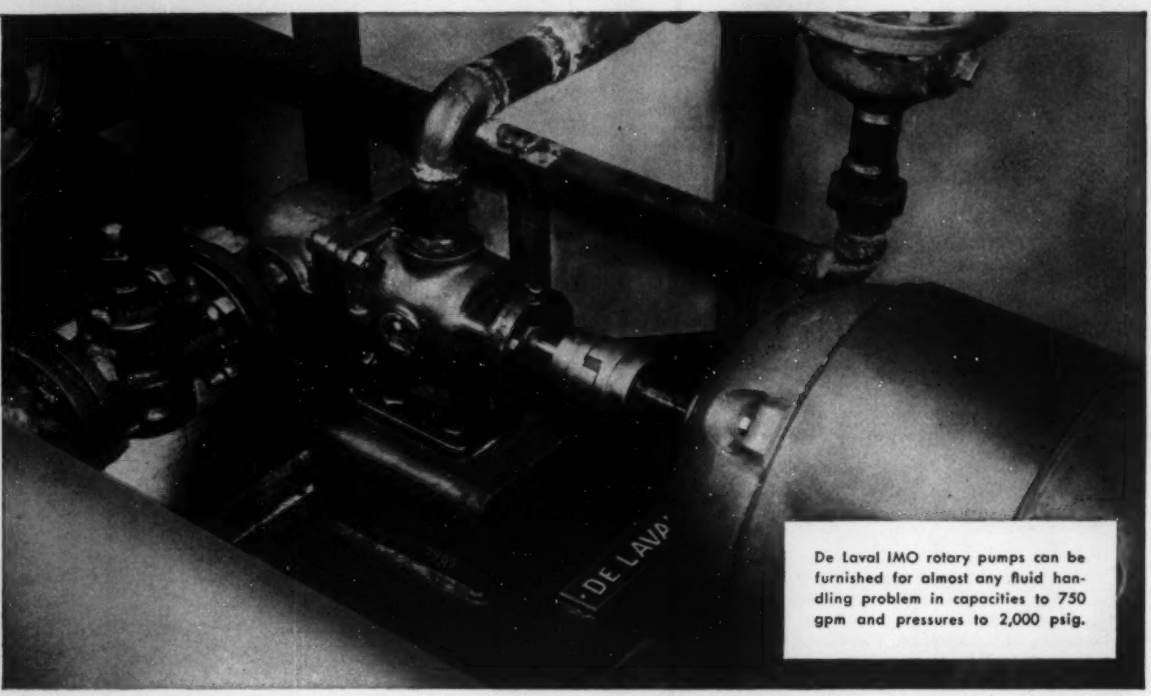
Through Mac's efforts, MICRO SWITCH has gained the added respect of this company.

MICRO SWITCH

A DIVISION OF MINNEAPOLIS-HONEYWELL REGULATOR COMPANY

In Canada, Leaside, Toronto 17, Ontario • FREEPORT, ILLINOIS

Circle 442 on page 19



De Laval IMO rotary pumps can be furnished for almost any fluid handling problem in capacities to 750 gpm and pressures to 2,000 psig.

What to Look for in a Rotary Screw Type Pump

By W. J. MONCON, *Assistant Chief Engineer*
De Laval Steam Turbine Company

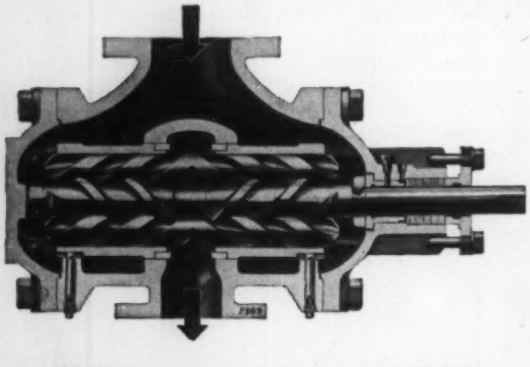
A sound knowledge of design, and how it affects performance, is the best insurance a buyer can have that he will get the pump he needs. This brief analysis of the IMO, a rotary three-screw pump manufactured by the De Laval Steam Turbine Company, will give you some of the necessary facts.

What qualities should you look for in a rotary type pump? It must, of course, meet specified capacities and pressures. But, it must also be efficient, operate quietly, stay on the job.

The axial flow of a screw type pump, and the resulting low inlet losses for any given pump speed, are important benefits that should be considered in making pump selections. The absence of timing gears and other mechanical features of construction also enable the De Laval IMO pump to operate at direct-connected motor and turbine speeds . . . to handle viscous liquids and high suction lifts.

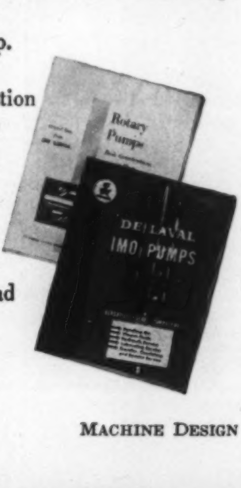
One of the most important features of the IMO pump is the hydraulic turning of the idler or sealing rotors. The central or power rotor is the pumping element; the liquid pumped turns the sealing rotors.

A screw type pump is well suited for applications where pulsation-free flow is desirable. The axial flow of the liquid without trapping and the unique thread form which keeps closures fluid-tight contribute to quiet operation of the IMO pump.



This is a cross-section of the De Laval IMO Series A322A, a positive displacement rotary screw type pump.

Catalog LS gives useful application and specification data on the IMO pump. An article titled, *Rotary Pumps, Basic Considerations in Their Application,* contains a description of rotary pumps in general. For these publications, write on your company letterhead to De Laval Steam Turbine Company, 858 Nottingham Way, Trenton 2, New Jersey. DL-301



"SUPER DYLAN* plastic motor shield has meant substantial sales increases"

. . . . . *says* R. H. SAWYER, *Lombard Governor Corp., Ashland, Mass.*

"Pioneering in lightweight precision-made chain saws, we feel we have helped change the woodcutting industry from a hand to a power operation," states Mr. Sawyer, Works Manager of the Lombard Corporation. "Lightness is so important in *all* component units that we use magnesium in some parts of the Lombard Chain Saw.

"In designing the motor shield, we tested many metals and plastics and decided that only Koppers SUPER DYLAN polyethylene offered the necessary strength, lightness and colorability coupled with a decided cost advantage. In use, the SUPER DYLAN shield weighs just six ounces including three metal screw inserts, is hard to the touch, protects the upper parts of the motor and gas tank, yet is flexible enough not to shatter or dent in rough use. And, of course, it's impervious to the weather. The shield's attractive design and brilliant red color have been real eye-catchers when our Lombard Chain Saw is on display in crowded stores. Its brightness acts like a stoplight for store traffic. We feel that SUPER DYLAN helps us maintain our claim of high quality and low price."

Have you thought of using a Koppers Plastic to help maintain a reputation of quality for *your* product? Many manufacturers are using Koppers SUPER DYLAN, DYLAN® polyethylene, DYLITE® expandable polystyrene or DYLENE® polystyrene to make their products more practical, marketable and profitable. For more information, write to Koppers Company, Inc., Dept. MD-57, Chemical Division, Pittsburgh 19, Pennsylvania.

**Koppers Trademark*

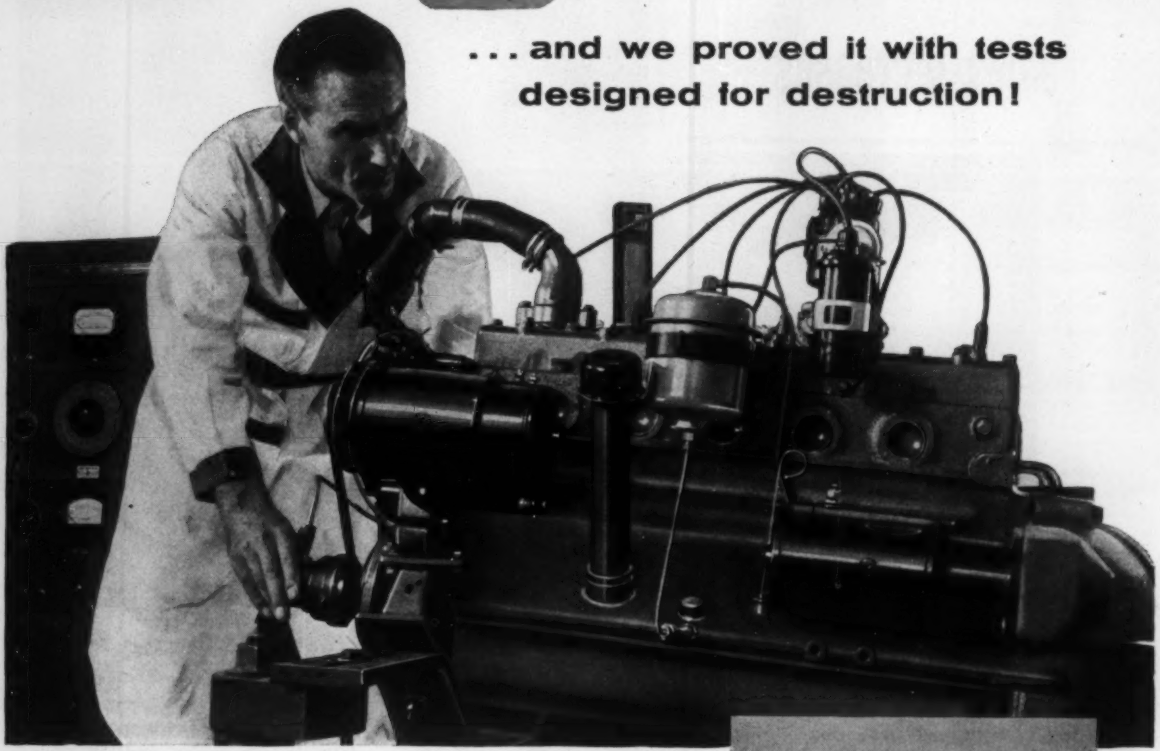
KOPPERS

KOPPERS PLASTICS

Sales Offices: PITTSBURGH • NEW YORK • BOSTON • PHILADELPHIA • ATLANTA • CHICAGO • DETROIT • HOUSTON • LOS ANGELES • SAN FRANCISCO
In Canada: Dominion Anilines and Chemicals Ltd., Toronto, Ontario

RUGGED

. . . and we proved it with tests designed for destruction!



WE pummeled the new Heavy Duty 'Jeep'-6 on the rack, in one high-speed torture test right after another. But we couldn't break this baby!

Each rugged test was the equivalent of 50,000 vehicle miles. Results after repeated tests: no breakdowns . . . no parts failures!

AND YOU GET NEW LUGGING POWER

New high torque gives you the extra lugging power you need when your equipment meets heavy loads at low rpm. Write today for full details and prices.

Also rugged Jeep 4 cyl. Industrial Engines and Power Units

'Jeep'-6
SPECIFICATIONS

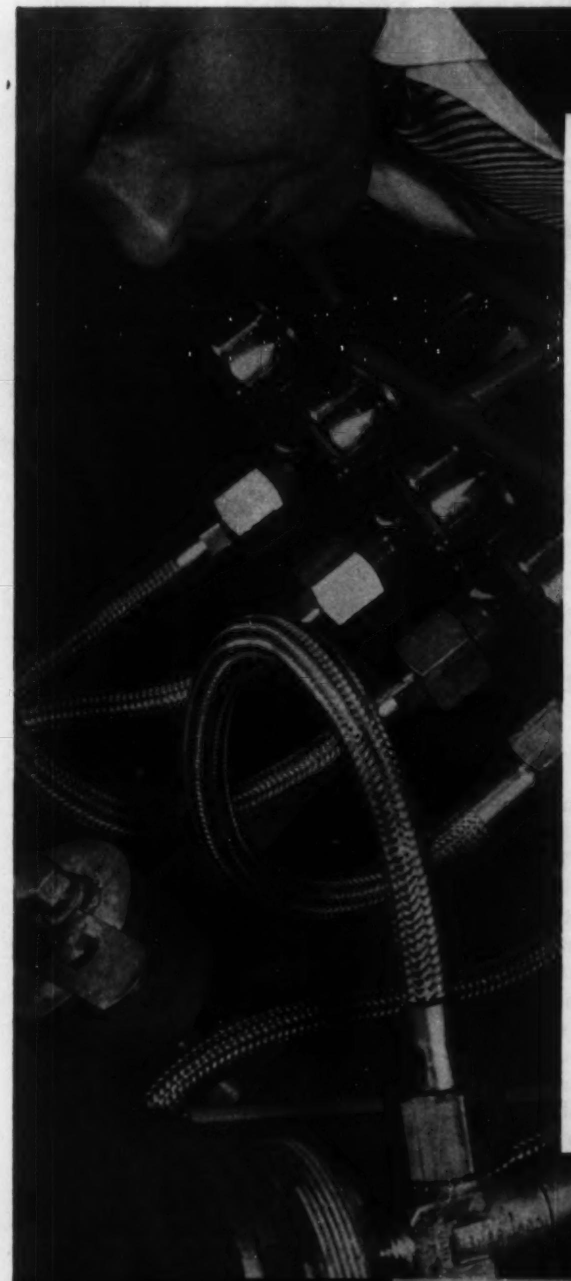
Continuous duty torque
1200-2600 rpm . . .
143-132 ft. lbs.
(peaks at 1200 rpm)

Continuous horsepower
1200-2600 rpm . . .
33-65 maximum*
***with accessories**

BUILT WITH Jeep RUGGEDNESS

WILLYS MOTORS, INC. *Industrial Engine Dept.* **Toledo, Ohio**

Circle 444 on page 19



Now...Local Availability on

Titeflex

Flexible Metal Hose

for conveying

"Problem" Liquids and Gases!

Titeflex Hose solves scores of problems in conveying organic and volatile liquids as well as corrosive gases. Connects moving and/or misaligned machine parts, other terminal joints. Withstands high extremes in temperature, pressure. Absorbs vibration, shock, and flexing . . . with ease. Sizes 3/16" to 3" Other tough conveyance problems are solved with Titeflex flexible hose made of TEFLON* in sizes of ¼" to 1¼".

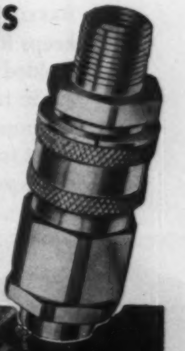
Titeflex

Quick-Seal Couplings

—the ideal "connecting mate" for Titeflex Hose or *any other kind of quality hose.* Connects or disconnects in ONE second and . . . the higher the pressure the tighter the seal!

Both these time-tested products are available for immediate shipment from distributors' stocks in most areas. Otherwise write, wire, or telephone direct.

*Du Pont trademark for its tetrafluoroethylene resin



CALL YOUR LOCAL DISTRIBUTOR

Consult the yellow pages of your telephone directory

Your one source for both Hose and Couplings

Titeflex

TITEFLEX, INC., 508 HENDEE STREET, SPRINGFIELD 4, MASS.

Designing with BAKELITE Plastics
BRAND

- ***Durability plus quality appearance***
- ***Precise small parts that resist chemicals***
- ***New trick with a coating***

Here are three materials whose properties can help you solve design problems. One is a general-purpose phenolic plastic notable for its strength and appearance. Another is C-11, a tough plastic that resists staining. The third is an abrasion-resistant vinyl organosol, a coating with eye-appeal to match its proven durability. These are just a sample. The hundreds of BAKELITE Brand Plastics provide a tremendous range of properties to improve design, effect production economies. Remember: Bakelite Company offers larger resources, longer experience, and a greater variety and number of plastics—vinyls, epoxies, polyesters, phenolics, polyethylenes, styrenes, silicones and impact styrenes.

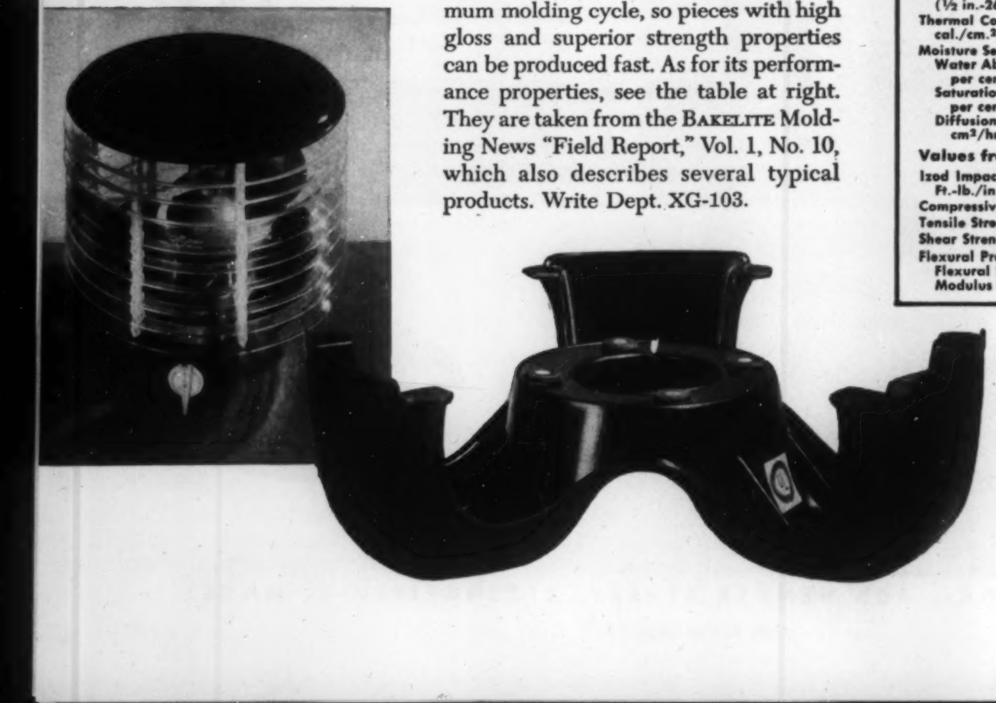
1

Designed for strength and beauty—with phenolic plastic above and below

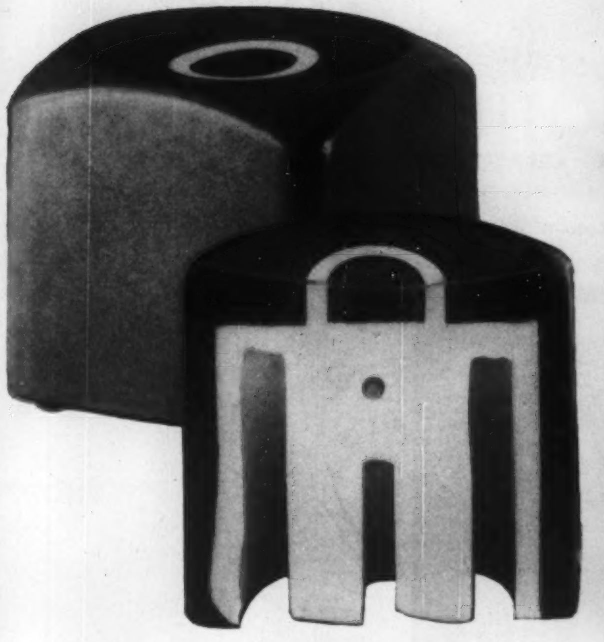
Where the treatment is roughest—on the cover and base—the manufacturer of this electric hassock fan uses parts molded of BAKELITE Brand Phenolic Plastic BMG-5000. This material keeps its fine surface finish and rich color. It provides cleanly-molded details that point up the fan's quality construction, and aid in fast, faultless assembly. And, as a sales point, the manufacturer emphasizes that the cover and base of the fan will resist food acids, beverages, soaps, and detergents. BMG-5000 offers your plastics molder the best combination of molding and end-use properties. It requires a minimum molding cycle, so pieces with high gloss and superior strength properties can be produced fast. As for its performance properties, see the table at right. They are taken from the BAKELITE Molding News "Field Report," Vol. 1, No. 10, which also describes several typical products. Write Dept. XG-103.

BMG-5000
Typical Test Values

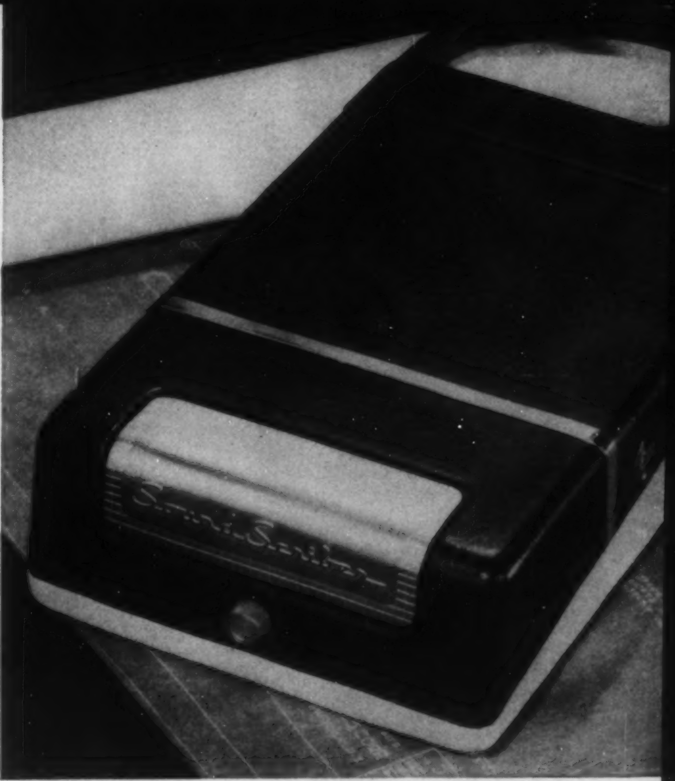
Values from Electrical Tests			
Dielectric Strength (D149-44) Short time, volts/mil	370		
Volume Resistivity (D257-54T) megohm-cm.	10^6		
	60 c.	1 kc.	1 mc.
Dielectric Constant (D150-54)	5.7	5.3	4.6
Dissipation Factor (D150-54)	0.07	0.04	0.03
Values from Miscellaneous Tests			
Molded Specific Gravity (D392-38)			
Black 25			1.34
Brown 15			1.36
Heat Distortion Temp. (648-45T), deg. F. (½ in.-264 psi)			330
Thermal Conductivity cal./cm.^{2}/sec./deg.C/cm.			5×10^{-4}
Moisture Sensitivity:			
Water Absorption (D570-54T) per cent wt. gain			.45
Saturation Constant (WC-78-B-2), per cent			8.0
Diffusion Constant (WC-78-E), cm^2/hr.			1.3×10^{-5}
Values from Mechanical Tests			
Izod Impact Strength (D256-54T) Ft.-lb./in. of notch			0.30
Compressive Strength (D695-54T), psi			34,000
Tensile Strength (D651-48) (⅛"), psi			8,400
Shear Strength (D732-46) (⅛"), psi			13,000
Flexural Properties (D790-49T):			
Flexural Strength, psi			10,000
Modulus of Elasticity in Flexure, psi			1×10^6



This "Air Flight" circulator has both cover and base molded of BAKELITE Phenolic Plastic BMG-5000. Note particularly the elaborate one-piece molded construction of the base.



"Two-shot" molded typewriter key—the outer shell is molded first, while the letter and the key lever slot are molded in the second shot to complete the button.



The leather-like textured finish gives the "Soundscriber 200" a high-quality look. And since the machine is portable, it is imperative that the finish be tough and abrasion-resistant—as soundly engineered as the machine itself.

2 "Two-shot" molded parts of C-11 Plastic—Highly Accurate, Tough, Chemical-Resistant

The key buttons above are typical of the small parts molded of Bakelite Brand C-11 Plastics for IBM electric typewriters and accounting machines. The choice of C-11 was based on its resistance to staining by inks, carbon paper, oil, and cleaning fluid, together with toughness, accuracy in molding, and smooth, comfortable finish. It can be made clear or colored . . . and is a plastic that can be used in many home products, packaging, and mechanical parts. Several other applications and properties of C-11 are discussed in Bakelite Molding News Vol. 1, No. 4. Write Dept. XH-103.

3 "Leather-textured" Vinyl Finish Designed to take hard knocks

The exterior finish of the "Soundscriber 200" portable dictating machine is a specially formulated organosol coating based on Bakelite Brand Vinyl Resins—able to take the knocks of travel and still look attractive. The leather-like textured finish gives the "200" a high-quality look. And since the machine is portable, it is imperative that the finish be tough and abrasion-resistant—as soundly engineered as the machine itself. Colors are virtually unlimited with organosols based on Bakelite Vinyl Resins. Write Dept. XK-103 for "Industrial Applications for Vinyl Resin Finishes."

See Bakelite Company exhibit
2nd Design Engineering Show
May 20-23, N. Y. Coliseum,
Booths #1005, 1009, 1013, 1019, 1023

There's more to design with in

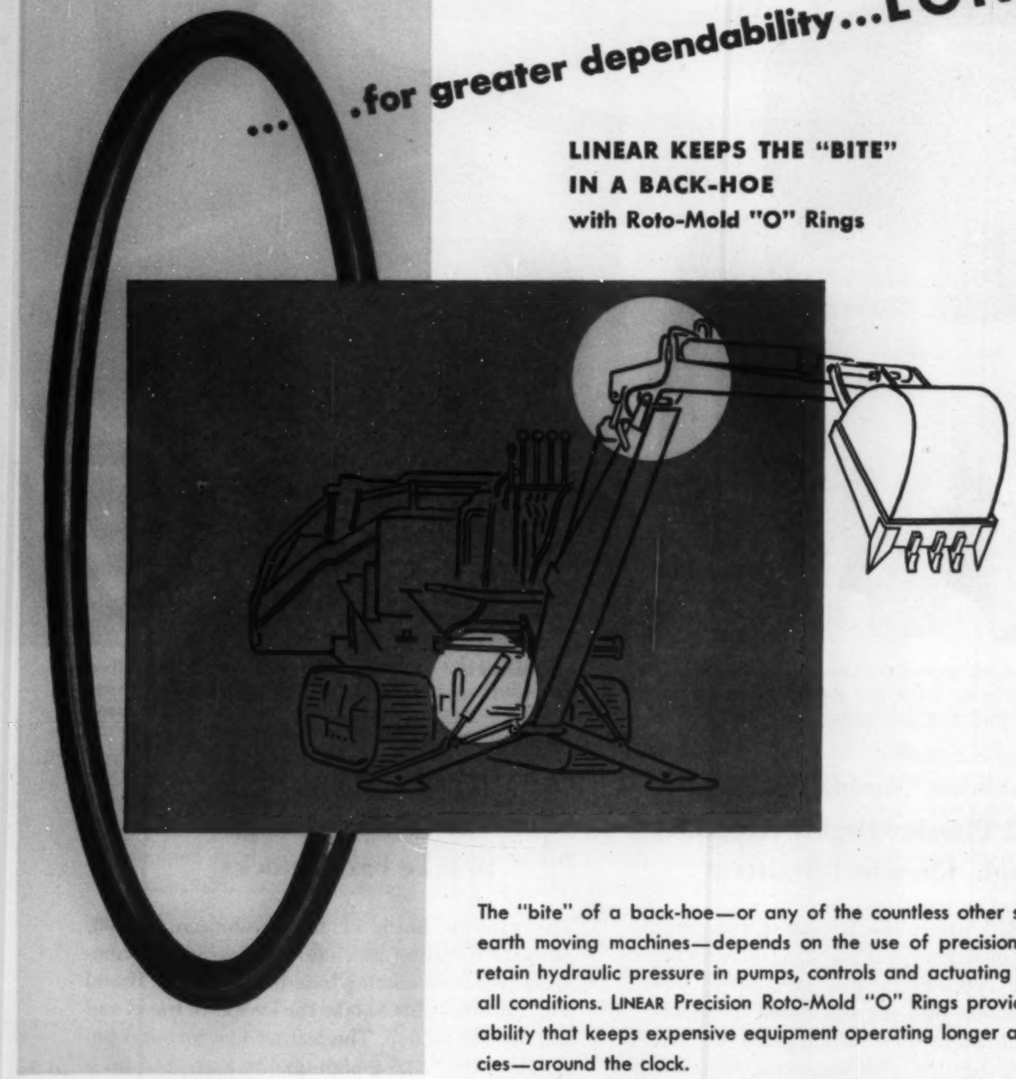
BAKELITE
BRAND
PLASTICS

POLYETHYLENES • SILICONES • POLYESTERS • EPOXIES
PHENOLICS • IMPACT STYRENES • STYRENES • VINYLS

BAKELITE COMPANY, *Division of Union Carbide Corporation* UCC 30 East 42nd Street, New York 17, N. Y.
In Canada: Bakelite Company, Division of Union Carbide Canada Limited, Belleville, Ontario
The term Bakelite and the Trefoil Symbol are registered trade-marks of UCC.

Circle 446 on page 19

. . . . .for greater dependability…LONGER



LINEAR KEEPS THE "BITE" IN A BACK-HOE

with Roto-Mold "O" Rings

The "bite" of a back-hoe—or any of the countless other small and large earth moving machines—depends on the use of precision seals that can retain hydraulic pressure in pumps, controls and actuating cylinders under all conditions. LINEAR Precision Roto-Mold "O" Rings provide the dependability that keeps expensive equipment operating longer at peak efficiencies—around the clock.

LINEAR'S extensive experience in working with all types of elastomers enables the selection of materials that can stand up under extreme temperature variations, continuous exposure to abrasive dirt and dust, and against surge pressures which may fluctuate to as much as 50,000 psi.

The exclusive Roto-Mold process makes possible precision "O" rings—physically better—free from foreign inclusions and flash. Another plus is scheduled deliveries at maximum economy.

No matter what your sealing problem may be—call on LINEAR or one of its agents for engineering assistance—and be sure to specify LINEAR Roto-Mold "O" Rings.

"PERFECTION IN RUBBER"

LINEAR

LINEAR, Inc., STATE ROAD & LEVICK ST., PHILA. 35, PA.

Circle 447 on page 19

carbon-stabilized

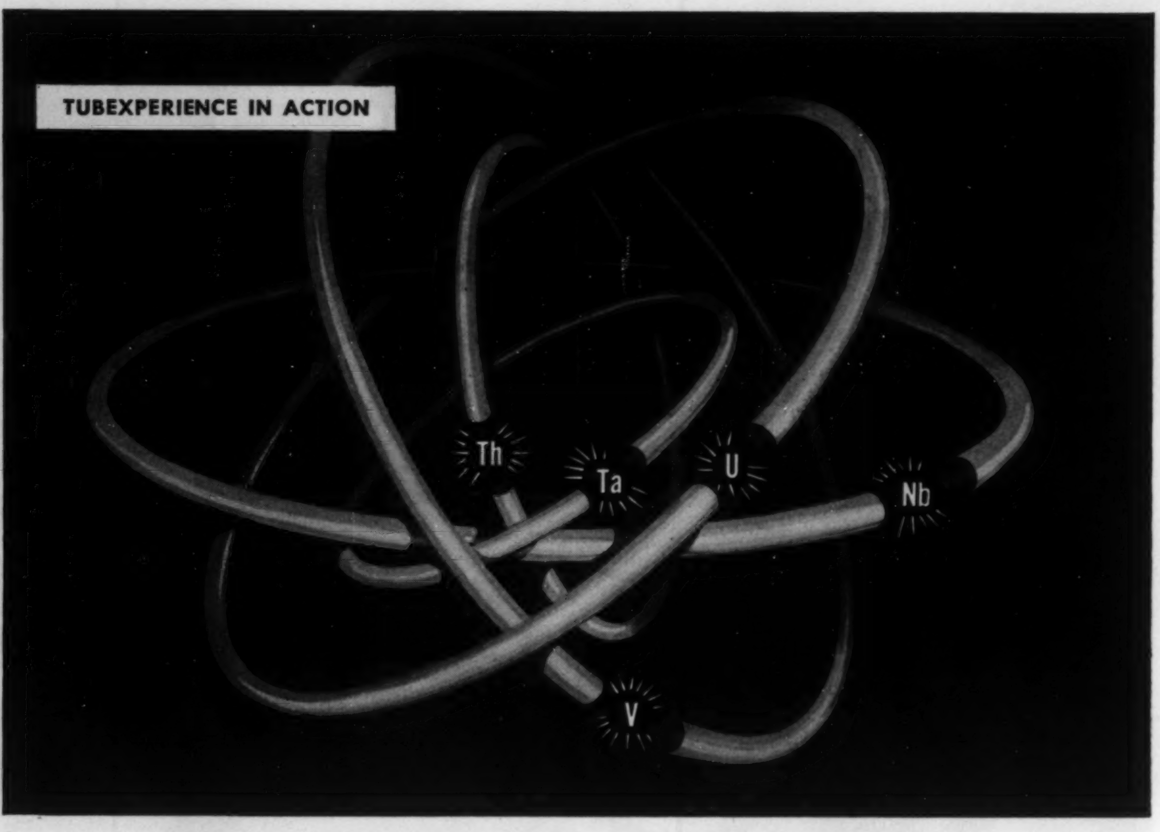
PARKER-KALON stress relieved socket screws

All P-K® Socket Screws are hardened in a propane atmosphere in this Westinghouse furnace to prevent carbon loss, eliminate adsorption of foreign gases. Part of P-K's controlled processing which assures consistent high quality, prevents precipitation or crystallization. Another good reason why . . . *If it's P-K . . . It's O-K!*

PARKER-KALON DIVISION, General American Transportation Corporation • Manufacturers of Socket Screws, Self-tapping Screws, Screwnails, Masonry Nails, Wing Nuts and Thumb Screws.

Sold Everywhere Through Leading Industrial Distributors — Factory: Clifton, New Jersey • Warehouses: Chicago, Illinois; Los Angeles, California

PARKER-KALON®
fasteners



NEED TUBING FOR ATOMIC POWER?

Superior is your most reliable, experienced source

PROOF:

- *Superior has supplied millions of feet of tubing for atomic applications to many of the key manufacturers in the atomic field.*
- *Superior has already successfully manufactured tubing from uranium, vanadium, niobium, tantalum and thorium.*
- *Superior has 9 years' experience in drawing tubing from titanium and titanium alloys.*
- *Superior was the first mill to produce tubing from Zirconium, Zircaloy-2, and Zircaloy-3.*

. . . And Superior has produced all this tubing to exceptionally precise specifications and tolerances!

Put Superior's experience and facilities to work for you! Superior has drawn most of the reactive metals, as well as stainless steels, nickel alloys, ingot iron, and Inconel, for important nuclear applications.

The end uses for Superior tubing in atomic energy include control rod tubing, fuel element tubing, tubing for moderator and shielding cans, process lines for handling radioactive liquids, and tubing for handling facilities.

NOTE: In some cases, tubing can be produced only with AEC release, because of priorities on materials.

If you are in or serving the atomic industry and need small tubing, this store of experience can be of great assistance to you. For information, write Superior Tube Company, 2010 Germantown Ave., Norristown, Pa.

SEND FOR LATEST DATA ON ZIRCONIUM—*Write for your free copy of Special Analysis Memo 112—on zirconium, covering properties, fabrication and other data.*

Superior Tube

The big name in small tubing

NORRISTOWN, PA.

All analyses .010 in. to ⅝ in. OD—certain analyses in light walls up to 2½ in. OD

West Coast: Pacific Tube Co., 5710 Smithway St., Los Angeles 22, Calif. • RAymond 3-1331

Using

DU PONT ELASTOMERS

NEOPRENE • HYPALON®

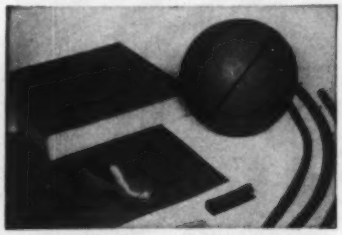
in Design

Coatings of HYPALON® add beauty and durability to a variety of products

Du Pont's new synthetic rubber, HYPALON, can now be applied as a protective coating on rubber, metal, wood or fabrics. It can be applied by spraying, brushing or spread coating. The development of these coatings, both clear and colored, has opened new avenues of product design in a wide range of applications. Here are the advantages such coatings offer: HYPALON is unaffected by ozone. It has unusual resistance to hardening at elevated temperatures (250°-350°F.). It is unique in its resistance to weathering and oxidizing chemicals. And, in addition to the protective benefits of HYPALON coatings, an unlimited range of stable colors is available to add beautiful and functional color to your products.

Applications for HYPALON coatings include tank linings, footwear, tarpaulins, camera bellows, hose, belts and automotive and sporting equipment. For other uses see the photograph below.

How can coatings of HYPALON fit into your design problems? Mail the coupon for more detailed information about your specific problem.



These products feature attractive protective coatings of HYPALON: a piece of corrugated rubber mat (left foreground); a coil of electrical wire, and a child's overshoe on the mat; rubber extrusions for automobile windshield frame and trunk weatherstripping (center foreground); door weatherstripping (right foreground); slab of urethane foam (left rear); basketball (right rear).

Circle 450 on page 19

NEOPRENE SEALS safeguard fuel line connections in the Douglas DC-7

SEAL READY FOR ASSEMBLY

Safety of passengers is uppermost in the minds of Douglas Aircraft designers—even down to as small an item as the rubber sleeve on a fuel line connector. Douglas uses the best metal connectors to join its fuel lines, but as an additional safety factor the company fits a vapor-tight sleeve seal over each joint which is vented by tubing to the ship's exterior to prevent any possible accumulation of highly flammable gasoline vapors within the fuselage.

Before switching to neoprene, Douglas had a problem with the seals. They required frequent replacement because ozone caused the rubber to crack. In fact, many of the rubber seals were rejected as unusable before installation because of ozone cracks which developed while the pre-assembled units were held in stock.

The installation of neoprene seals proved to be the answer to the problem. Neoprene was chosen because it resists ozone, gasoline, oil and aging. Many of the neoprene seals have been in service for over two years, reducing maintenance and replacement costs.

Perhaps your design problems can be solved by the use of Du Pont neoprene. We'd be glad to send you further information—property data and proven applications. If you have a specific problem, please let us know in the coupon.

NEOPRENE SEALS (in red) resist ozone, oil, gasoline and aging. Many of them have lasted for over 2 years.

DU PONT
REG. U. S. PAT. OFF.

HYPALON *is a registered trademark of E. I. du Pont de Nemours & Co (Inc.)*

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

ELASTOMERS

☐ I am particularly interested in ____________________

____

☐ Please add my name to the mailing list for your free publication "The Du Pont Elastomers."

Name ________________ Position __________

Firm ____________________________

Address __________________________

City ________________ State __________

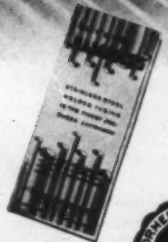
E. I. du Pont de Nemours & Co. (Inc.)
Elastomer Chemicals Dept. MD-5
Wilmington 98, Delaware

WE RESPECT YOUR SPECIFICATION

- Strict adherence to chemistry requirements for standard or special specifications.
- Full relief of cold work stresses.
- Complete carbide dissolution.
- Dimensional accuracy.
- Rigid quality control assured by thorough testing.

For stainless steel tubing or pipe, guaranteed to meet your exact specifications—remember Damascus.

Write for
free booklet
today

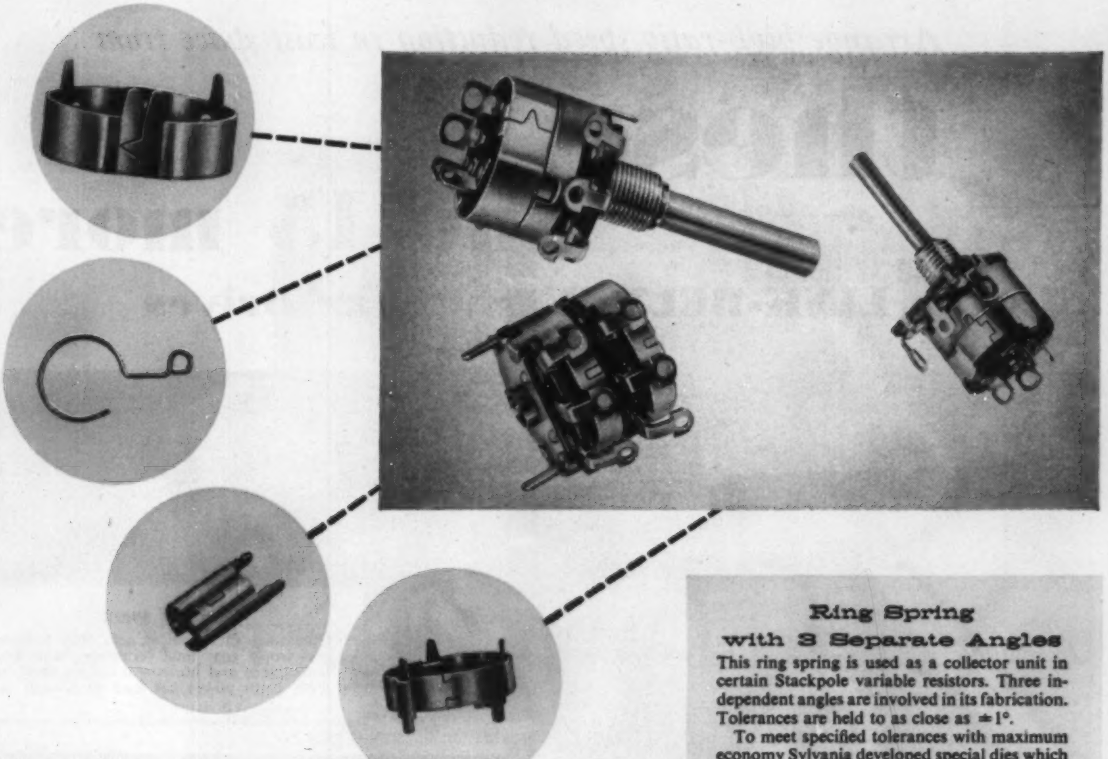


DAMASCUS TUBE COMPANY

STAINLESS STEEL TUBING AND PIPE
GREENVILLE, PENNSYLVANIA

FORMED STEEL TUBE INSTITUTE

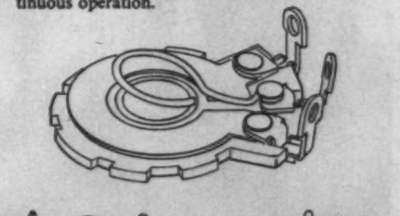
Circle 451 on page 19

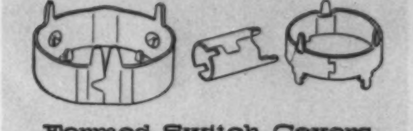


Ring Spring with 3 Separate Angles

This ring spring is used as a collector unit in certain Stackpole variable resistors. Three independent angles are involved in its fabrication. Tolerances are held to as close as ±1°.

To meet specified tolerances with maximum economy Sylvania developed special dies which accomplish flat forming and bending as a continuous operation.





Formed Switch Covers and Shaft

These are typical metal stampings used in certain Stackpole variable resistors. Sylvania's experience and know-how in fabricating small parts result in high volume production at low costs. Hollow shaft is carefully formed to hold diameter within ±.0025". Dovetail on large cover was designed by Sylvania to avoid nestling and tangling of parts during handling.

Formed metal parts

from Sylvania help assure inherent quality of STACKPOLE variable resistors

Stackpole designs and manufactures components to meet high standards of quality in electrical-electronic products.

For precision and uniformity in the volume production of critical metal parts used in variable resistors, the Stackpole Carbon Company relies on Sylvania's Parts Division.

Many leading manufacturers, large and small, use Sylvania's 4-way service for high volume production of close tolerance parts. Let us submit a quotation on your specifications calling for custom-molded plastic parts . . . plated or clad specialty wire . . . electronic components . . . or formed metal parts.

For information on our facilities write for free copy of: "Portfolio of 4-way Service to Designers."

SYLVANIA PARTS DIVISION

Sylvania Electric Products Inc., Parts Division, Warren, Pennsylvania

LIGHTING • RADIO • ELECTRONICS • TELEVISION • ATOMIC ENERGY

SPECIAL WIRE

METAL STAMPINGS

MOLDED PLASTIC

ELECTRONIC COMPONENTS

4-way service from one source

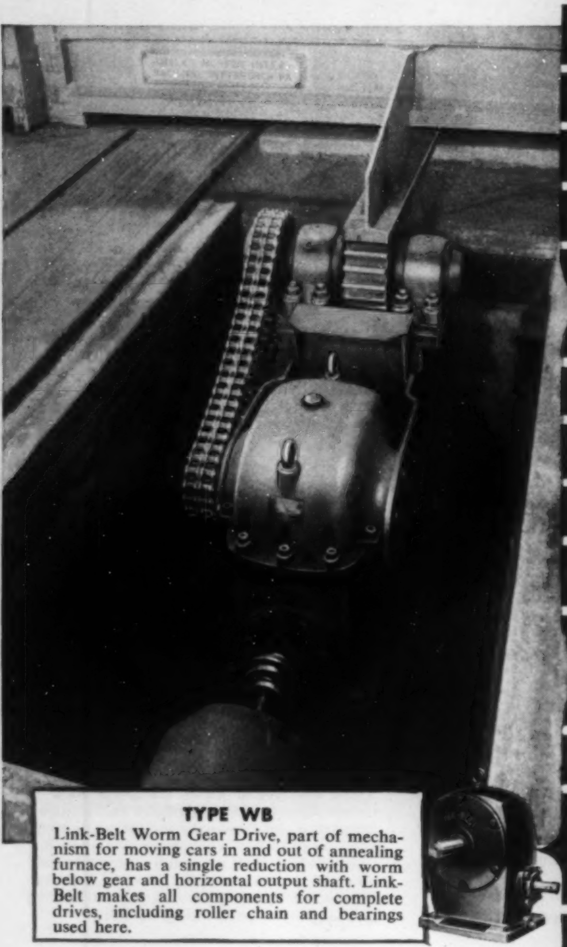
"SEE US AT BOOTH 110 AT THE DESIGN ENGINEERING SHOW"

Circle 452 on page 19

Arrange high-ratio speed reduction in least space from

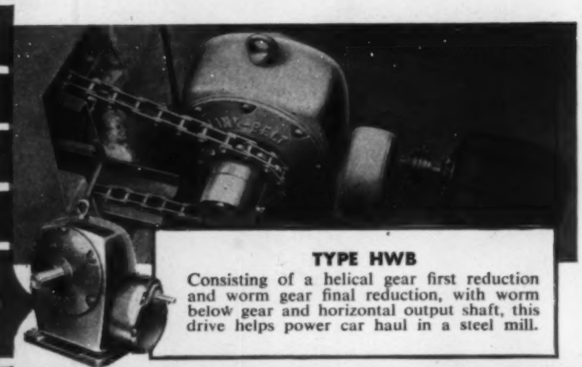
these 4 and 15 more

LINK-BELT Worm Gear Drives



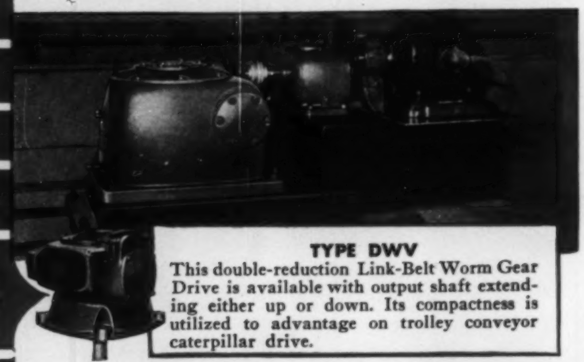
TYPE WB

Link-Belt Worm Gear Drive, part of mechanism for moving cars in and out of annealing furnace, has a single reduction with worm below gear and horizontal output shaft. Link-Belt makes all components for complete drives, including roller chain and bearings used here.



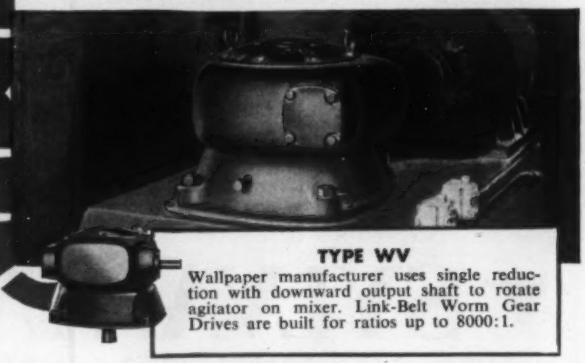
TYPE HWB

Consisting of a helical gear first reduction and worm gear final reduction, with worm below gear and horizontal output shaft, this drive helps power car haul in a steel mill.



TYPE DWV

This double-reduction Link-Belt Worm Gear Drive is available with output shaft extending either up or down. Its compactness is utilized to advantage on trolley conveyor caterpillar drive.



TYPE WV

Wallpaper manufacturer uses single reduction with downward output shaft to rotate agitator on mixer. Link-Belt Worm Gear Drives are built for ratios up to 8000:1.

ADD to basic compactness the application flexibility offered by 19 types — and you'll find the perfect mating of speed and need in the complete Link-Belt line of Worm Gear Drives. For selection guidance and full data, ask your nearest Link-Belt office for copy of 80-page Book 2324-A.

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World.

LINK-BELT

ENCLOSED DRIVES

14,307

"Visit Our Exhibit, Space 31—Design Engineering Show, New York Coliseum, May 20-23"

Circle 453 on page 19

MACHINE DESIGN
May 2, 1957

The Human Side

"THE KNOWLEDGE collected by scientists does not automatically transform itself into something useful to society." Thus Herbert A. Shepard, in the *Journal of Engineering Education,* neatly points up the role of engineers. But this role, he suggests, places engineers on the fringes of two cultures with incompatible value systems—science and business. In this respect they are in the same quandary as so-called "marginal" men.

As the strategic link between science which pursues knowledge, and business which pursues profit, engineers are indeed subject to conflicting tensions. Only with money from the world of business can they translate the findings of the world of science into hardware for the benefit of mankind. Therefore they must understand and gain the confidence of both worlds.

If engineers are too science-oriented, businessmen regard them as long hairs. If they are too practical, scientists scorn them as "mere technicians." To have gotten along as well as they have with both worlds, engineers evidently do not altogether lack skill in the art of human relations—popular impressions to the contrary notwithstanding.

Understanding what makes people tick—including themselves—most surely spells the difference between success and failure for "marginal" men such as engineers. For this reason we are particularly happy to be able to present the articles by Dr. Edwin C. Nevis on the personal side of engineering, the second of which appears on Page 109 of this issue. We hope they will help all engineers perform even more effectively in their challenging role.

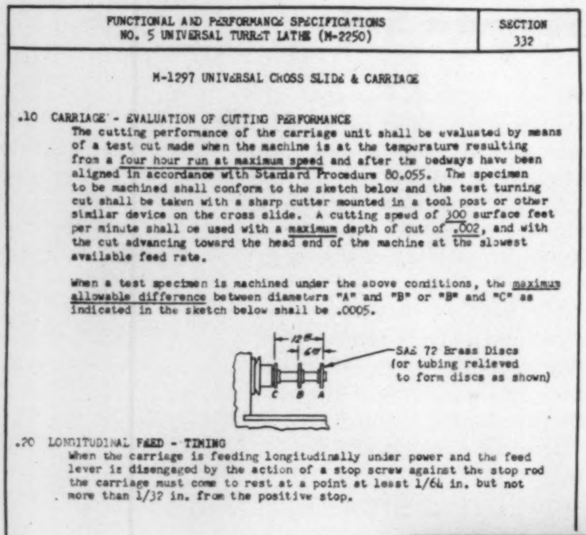
Colin Carmichael

EDITOR

Standards for Performance

By M. W. Papp,
Standards Engineer
The Warner & Swasey Co., Cleveland

THE THEORY behind formal performance standards is not new. Every manufacturer has final inspectors that check to see if the final product "works." Performance standards merely state formally *how well* the product must work. If precise values are not assigned for the functioning of the whole, the various parts may be either of insufficient or of excessive quality.


FUNCTIONAL AND PERFORMANCE SPECIFICATIONS
NO. 5 UNIVERSAL TURRET LATHE (M-2250)

SECTION
332

M-1297 UNIVERSAL CROSS SLIDE & CARRIAGE

.10 CARRIAGE - EVALUATION OF CUTTING PERFORMANCE
The cutting performance of the carriage unit shall be evaluated by means of a test cut made when the machine is at the temperature resulting from a four hour run at maximum speed and after the bedways have been aligned in accordance with Standard Procedure 80.055. The specimen to be machined shall conform to the sketch below and the test turning cut shall be taken with a sharp cutter mounted in a tool post or other similar device on the cross slide. A cutting speed of 300 surface feet per minute shall be used with a maximum depth of cut of .002, and with the cut advancing toward the head end of the machine at the slowest available feed rate.

When a test specimen is machined under the above conditions, the maximum allowable difference between diameters "A" and "B" or "B" and "C" as indicated in the sketch below shall be .0005.

SAE 72 Brass Discs (or tubing relieved to form discs as shown)

.20 LONGITUDINAL FEED - TIMING
When the carriage is feeding longitudinally under power and the feed lever is disengaged by the action of a stop screw against the stop rod the carriage must come to rest at a point at least 1/64 in. but not more than 1/32 in. from the positive stop.

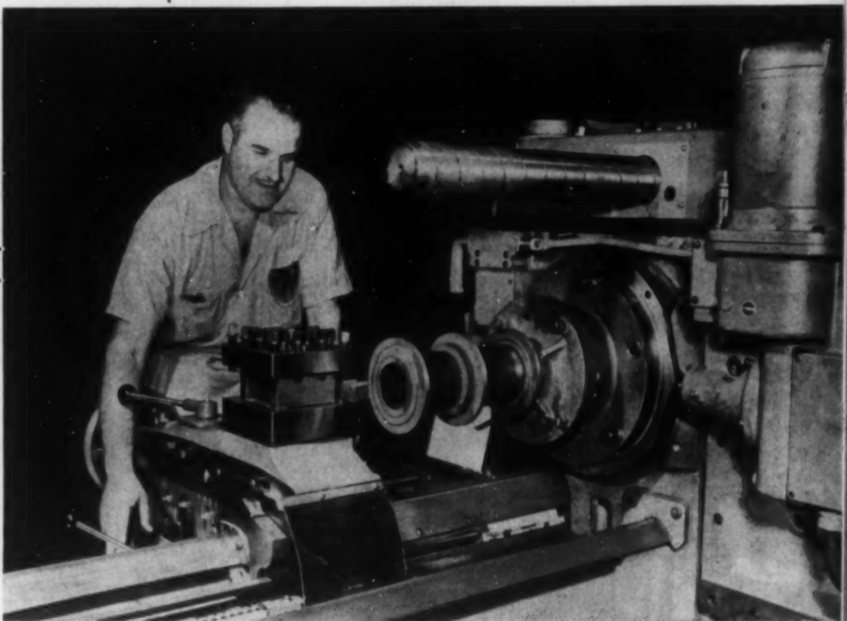
DATE 2-12-57 REVISED

Fig. 1—Functional and performance specification for evaluating precision of cross slide and carriage of turret lathe. Specification pinpoints exact functional requirement of completed machine.

In the "good old days" when machines were comparatively simple, their functional quality was usually evaluated by the instinct, skill and experience of the chief inspector. He was expected to reject those products which in his personal judgment were not up to standard, although it is doubtful if the desired standard was ever actually defined. Under the circumstances, however, he did a creditable job in maintaining satisfactory levels of quality.

But, circumstances are different today. The quality of a modern machine, often with complicated functions and design features, has become a rather involved consideration. It was realized at Warner & Swasey that personal judgment must be minimized in the evaluation of the product. To secure an accurate and consistent appraisal of quality and performance, some form of systematic program was necessary. First it was necessary to pin-point what was needed. Once existing and anticipated conditions were defined, a program could be devised to effect the transition.

Program Objectives: In the past, the problem was basically one of communication. There was no



Quality

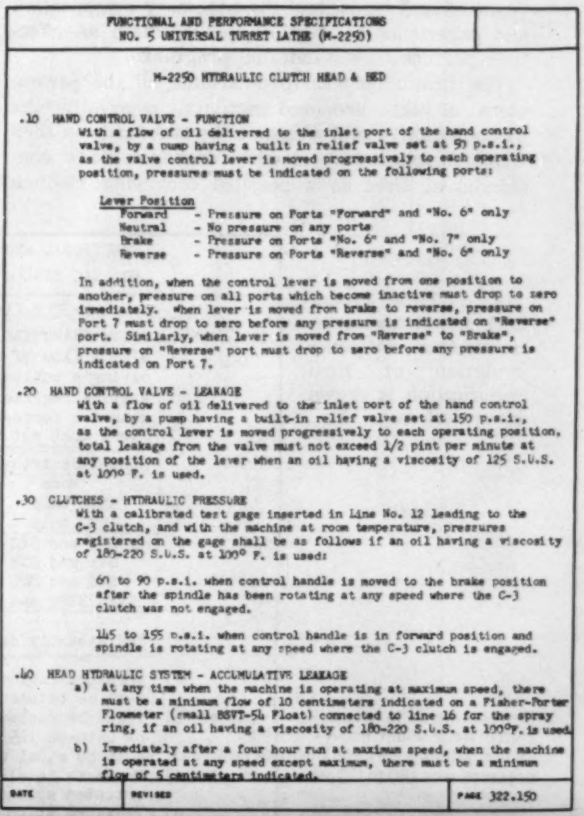
Performance standards go beyond the blueprint. The blueprint tells what a part or a product *is*. Performance standards define what it must *do*.

established medium for transmitting certain types of technical engineering information to other interested divisions of the company. This information, pertaining to the overall function and intended performance of a design, was usually on record only in the minds of the engineers who did the designing, or the lab technicians who ran qualifications tests on pilot models. A suitable means for conveying the data to the people who had to build, evaluate, or sell the equipment was badly needed.

A formal program, it was felt, should achieve a number of objectives:

1. To establish a means for transmitting product-quality information to all interested divisions of the company simultaneously.
2. To eliminate or minimize the effects of personal judgment or opinion in the evaluation of finished products and thereby eliminate controversy between manufacturing and inspection.

Fig. 2—Specifications, right, dictate performance testing of hydraulic clutch. As a subassembly, valves are run on test rig, below, to evaluate performance. After installation, entire unit is checked with testing-head mounted temporarily on machine, below right.



FUNCTIONAL AND PERFORMANCE SPECIFICATIONS
NO. 5 UNIVERSAL TURRET LATHE (M-2250)

M-2250 HYDRAULIC CLUTCH HEAD & BED

.10 HAND CONTROL VALVE - FUNCTION
With a flow of oil delivered to the inlet port of the hand control valve, by a pump having a built in relief valve set at 50 p.s.i., as the valve control lever is moved progressively to each operating position, pressures must be indicated on the following ports:

Lever Position
Forward - Pressure on Ports "Forward" and "No. 6" only
Neutral - No pressure on any ports
Brake - Pressure on Ports "No. 6" and "No. 7" only
Reverse - Pressure on Ports "Reverse" and "No. 6" only

In addition, when the control lever is moved from one position to another, pressure on all ports which become inactive must drop to zero immediately. When lever is moved from brake to reverse, pressure on Port 7 must drop to zero before any pressure is indicated on "Reverse" port. Similarly, when lever is moved from "Reverse" to "Brake", pressure on "Reverse" port must drop to zero before any pressure is indicated on Port 7.

.20 HAND CONTROL VALVE - LEAKAGE
With a flow of oil delivered to the inlet port of the hand control valve, by a pump having a built-in relief valve set at 150 p.s.i., as the control lever is moved progressively to each operating position, total leakage from the valve must not exceed 1/2 pint per minute at any position of the lever when an oil having a viscosity of 125 S.U.S. at 100° F. is used.

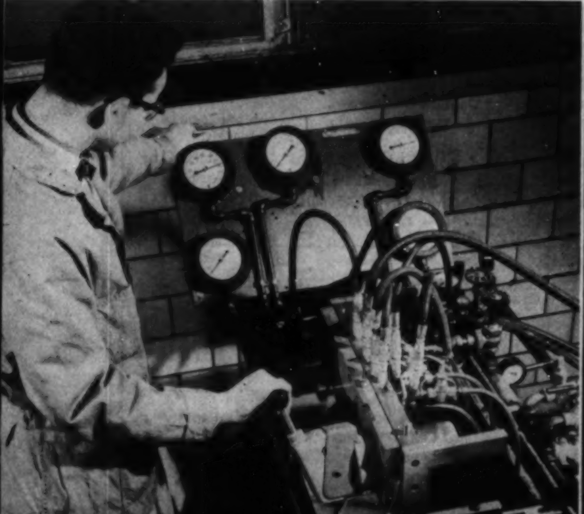
.30 CLUTCHES - HYDRAULIC PRESSURE
With a calibrated test gage inserted in Line No. 12 leading to the C-3 clutch, and with the machine at room temperature, pressures registered on the gage shall be as follows if an oil having a viscosity of 180-220 S.U.S. at 100° F. is used:

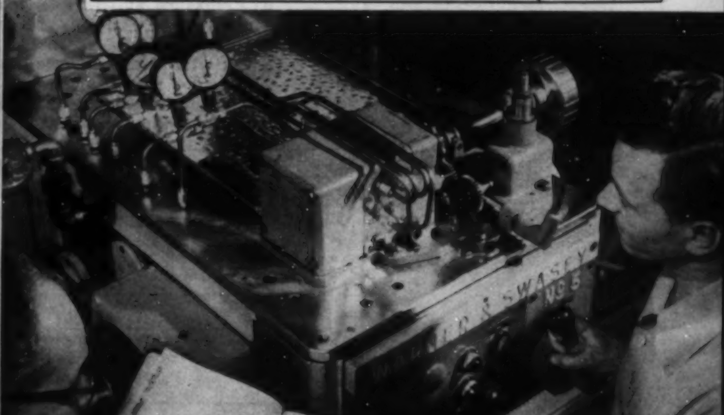
60 to 90 p.s.i. when control handle is moved to the brake position after the spindle has been rotating at any speed where the C-3 clutch was not engaged.

145 to 155 p.s.i. when control handle is in forward position and spindle is rotating at any speed where the C-3 clutch is engaged.

.40 HEAD HYDRAULIC SYSTEM - ACCUMULATIVE LEAKAGE
a) At any time when the machine is operating at maximum speed, there must be a minimum flow of 10 centimeters indicated on a Fisher-Porter Flowmeter (small BSVT-54 Float) connected to line 16 for the spray ring, if an oil having a viscosity of 180-220 S.U.S. at 100°F. is used.
b) Immediately after a four hour run at maximum speed, when the machine is operated at any speed except maximum, there must be a minimum flow of 5 centimeters indicated.

DATE | REVISED | PAGE 322.150





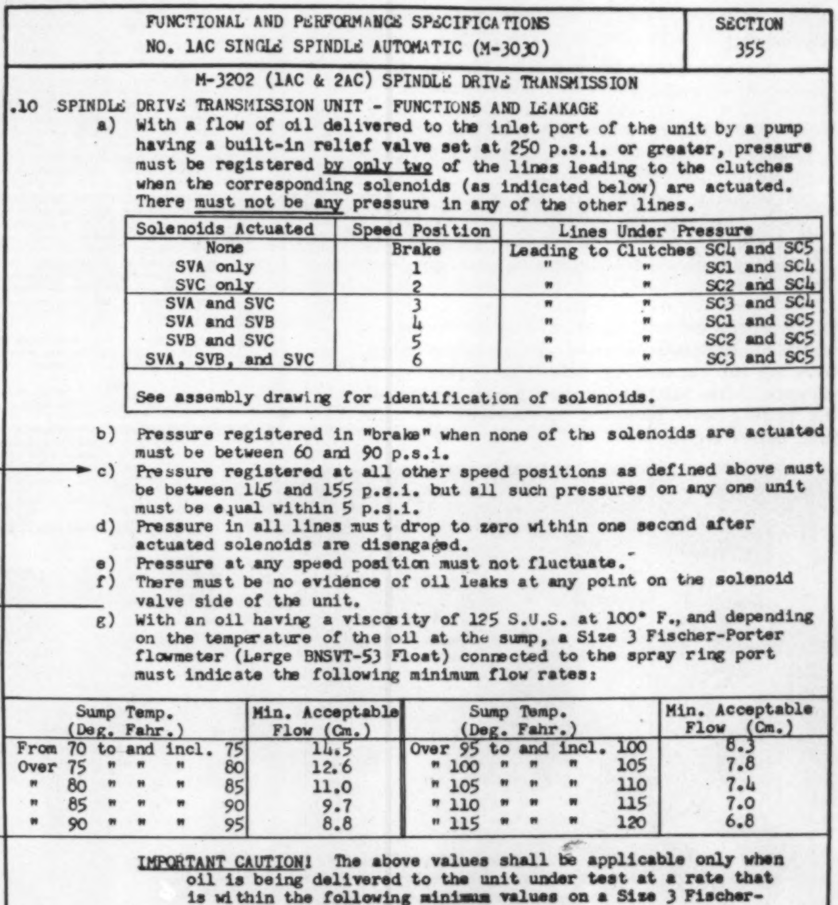
3. To rapidly pass on to customers the benefits of developments accruing from the continuous search for ways to improve accuracy and durability of the products.
4. To reduce the cost of field service by establishing definite standards of performance and making sure that every machine meets those standards before it is shipped.

The Approach: The responsibility for finding a practical solution to the problem was delegated to the engineering-standards department. This group, which was already responsible for several other types of standards, had the necessary organization and experience to develop and maintain an effective performance-standards program.

The first step was to determine all the parameters of the proposed activity, especially the medium that would transmit the standards as they were established. Assembly drawings were considered at first as a possible conveying medium but were ruled out because of space limitations. After several other trial approaches which proved only mildly effective, a means was devised for communicating quality requirements through functional and performance specifications, Figs. 1, 2 and 3. This made possible the adoption of a workable system that has been in use since. Before such a system could be developed, however, several basic concepts had to be established so that the needs of all company operating divisions would be equitably served. In effect, these concepts defined certain organizational responsibilities, but more important, they provided the basis for the entire program:

1. A functional or performance specification must clearly define, in specific terms and measurable values, the operating results desired from a subunit, a mechanism, or a complete machine. It should contain no reference to methods of manufacture, assembly, or fabrication, except in

Fig. 3—How experience and changing requirements influence evolution of final specification is shown by typical case.



FUNCTIONAL AND PERFORMANCE SPECIFICATIONS NO. 1AC SINGLE SPINDLE AUTOMATIC (M-3030)	SECTION 355

M-3202 (1AC & 2AC) SPINDLE DRIVE TRANSMISSION

.10 SPINDLE DRIVE TRANSMISSION UNIT - FUNCTIONS AND LEAKAGE

a) With a flow of oil delivered to the inlet port of the unit by a pump having a built-in relief valve set at 250 p.s.i. or greater, pressure must be registered by only two of the lines leading to the clutches when the corresponding solenoids (as indicated below) are actuated. There must not be any pressure in any of the other lines.

Solenoids Actuated	Speed Position	Lines Under Pressure
None	Brake	Leading to Clutches SC4 and SC5
SVA only	1	" " SC1 and SC4
SVC only	2	" " SC2 and SC4
SVA and SVC	3	" " SC3 and SC4
SVA and SVB	4	" " SC1 and SC5
SVB and SVC	5	" " SC2 and SC5
SVA, SVB, and SVC	6	" " SC3 and SC5
See assembly drawing for identification of solenoids.		

b) Pressure registered in "brake" when none of the solenoids are actuated must be between 60 and 90 p.s.i.

c) Pressure registered at all other speed positions as defined above must be between 145 and 155 p.s.i. but all such pressures on any one unit must be equal within 5 p.s.i.

d) Pressure in all lines must drop to zero within one second after actuated solenoids are disengaged.

e) Pressure at any speed position must not fluctuate.

f) There must be no evidence of oil leaks at any point on the solenoid valve side of the unit.

g) With an oil having a viscosity of 125 S.U.S. at 100° F., and depending on the temperature of the oil at the sump, a Size 3 Fischer-Porter flowmeter (Large BNSVT-53 Float) connected to the spray ring port must indicate the following minimum flow rates:

Sump Temp. (Deg. Fahr.)	Min. Acceptable Flow (Cm.)	Sump Temp. (Deg. Fahr.)	Min. Acceptable Flow (Cm.)
From 70 to and incl. 75	14.5	Over 95 to and incl. 100	8.3
Over 75 " " " 80	12.6	" 100 " " " 105	7.8
" 80 " " " 85	11.0	" 105 " " " 110	7.4
" 85 " " " 90	9.7	" 110 " " " 115	7.0
" 90 " " " 95	8.8	" 115 " " " 120	6.8

IMPORTANT CAUTION! The above values shall be applicable only when oil is being delivered to the unit under test at a rate that is within the following minimum values on a Size 3 Fischer-Porter Flowmeter (Large BNSVT-53 Float):

Temp of Test Oil (Deg. Fahr.)	Min. Acceptable Flow (Cm.)	Temp. of Test Oil (Deg. Fahr.)	Min. Acceptable Flow (Cm.)
From 70 to and incl. 75	19.4	Over 90 to and incl. 95	15.4
" 75 " " " 80	17.8	" 95 " " " 100	14.6
" 80 " " " 85	17.0	" 100 " " " 105	14.2
" 85 " " " 90	16.2	" 105 " " " 110	14.0

Revision made to reduce clutch wear under heavy-load conditions. Original pressure was 120 to 130 psi

Revision resulting from changing testing oil from 200 to 125 S.U.S.

Addition to eliminate inconsistencies in evaluations those cases where a measurable value cannot otherwise be assigned to the desired result.

2. A functional or performance specification must be recognized and applied as a specific and independent engineering requirement. It shall have the same connotations as a dimension on a drawing, and shall be subject to a similar degree of evaluation and enforcement.

3. All functional or performance specifications shall be gathered, edited, distributed, and maintained by a central authority (currently the engineering-standards department). They shall be incorporated in a centralized reference source apart from engineering drawings, and shall be made available to any interested department or division of the company.

Typical Case History: The spindle-drive transmission specification, Fig. 3, covering function of the unit, shows how a final specification is evolved.

The original specifications relating to these factors were established by the engineering department before the first machine was shipped in February 1954. The values included, however, were

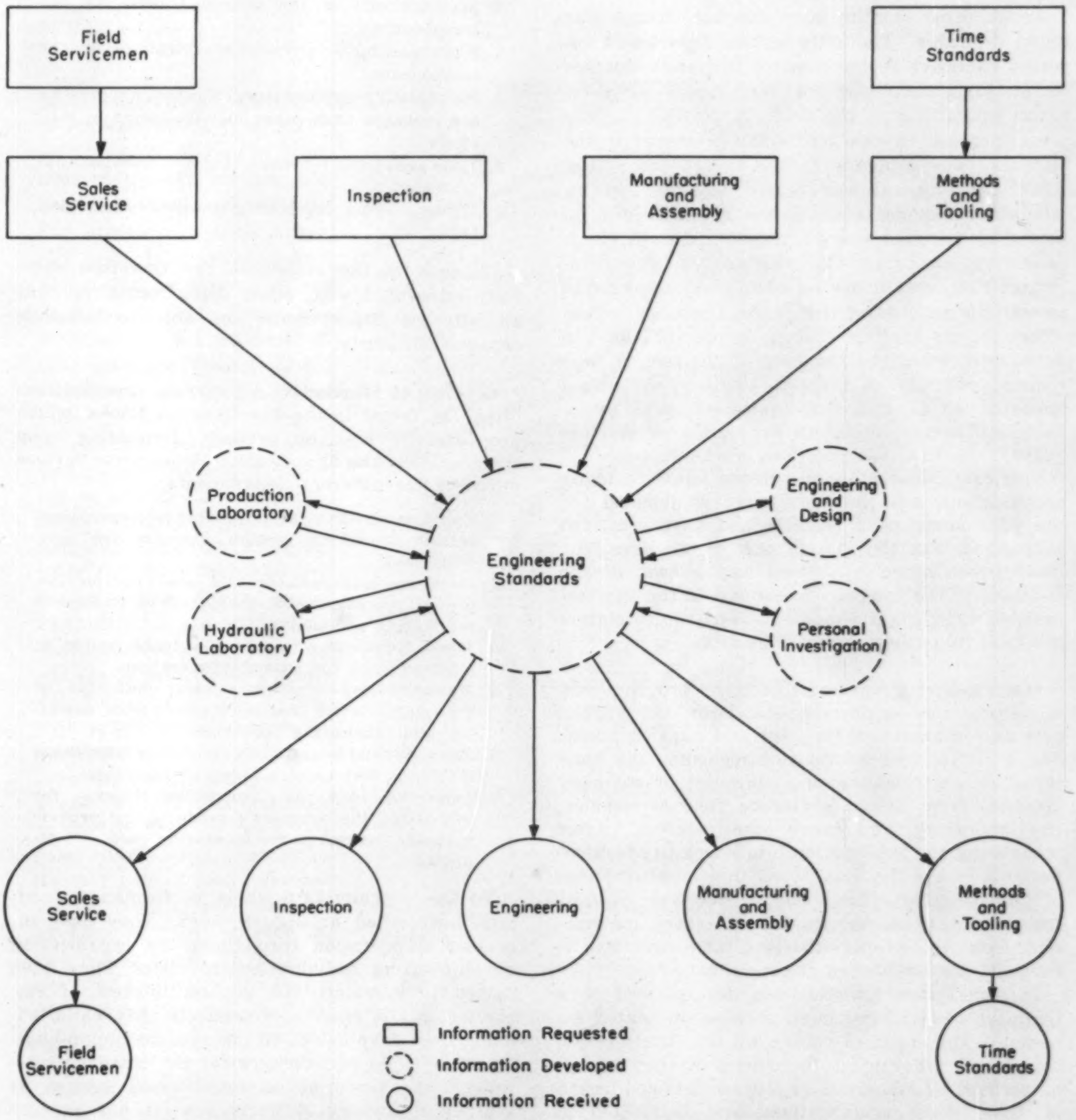

Field Servicemen
Time Standards
Sales Service
Inspection
Manufacturing and Assembly
Methods and Tooling
Production Laboratory
Engineering and Design
Engineering Standards
Hydraulic Laboratory
Personal Investigation
Sales Service
Inspection
Engineering
Manufacturing and Assembly
Methods and Tooling
Field Servicemen
Time Standards
Information Requested
Information Developed
Information Received

Fig. 4—Flow diagram shows departments and activities that originate requests and suggestions concerning proposed specifications or revisions to existing ones. Engineering-standards department performs tests and evaluates data, issuing approved specifications to departments concerned.

calculated or theoretical appropriations which could only be verified empirically. They were carefully observed for almost 18 months by laboratory and inspection personnel who gathered actual operating data on the new machines being built during that period. In July 1955, based on the data accumulated, the laboratory was able to recommend changes in specifications that would upgrade the quality of the machines. The recommendations were adopted and put into effect immediately throughout the organization by the issuance of new specifications.

About three months later another change was found desirable. The sales-service department reported excessive replacement of hydraulic clutches on machines employed for very heavy metal-removal operations in the field. A possible remedy—an increase in the hydraulic pressure to the clutches—was proposed to the design committee. After the proposal was judged feasible through laboratory experimentation, the specifications involved in the change were revised and redistributed. In the meantime, the laboratory continued investigations toward development of more accurate means for evaluating hydraulic functions. That effort led to another change in specifications in June 1956, when the viscosity of the test oil was reduced. Finally in October 1956, when control limits of oil flow in test equipment were established to assure consistent evaluation of product quality, the final specifications were adopted.

This case, however, is an extreme example. Many specifications now in effect were established for the pilot model of a machine and have remained unchanged. But the system now in use does lend itself to changing conditions and allows all the divisions of the company to receive, in the shortest possible time, all the most up-to-date information available regarding product quality.

Operation of Program: Under the program now in effect, the engineering-standards department acts as a central control point and clearing house, Fig. 4. It receives information regarding the functional or performance characteristics of company products from design engineers, field servicemen, the laboratory, and many other sources. After translating the information into terms of specifications, it issues the data to all interested divisions of the company. Conversely, it receives requests for specifications, solicits the necessary information from the proper divisions, and circulates it through the established channels.

In some cases specifications are released on a tentative basis. Sometimes, because of limited experience, the specified values are not firmly established and are subject to revision if they cannot be verified by actual use in a predetermined length of time. Such specifications are distributed in loose sheet form and are accompanied by verification memorandums. The divisions or activities affected apply them during a trial period, and evalute them on the memorandum which is returned to the engineering-standards department. After this trial run the specifications are revised if necessary on the basis of the evaluations submitted and then become a part of the standard functional and performance specification books located at strategic points throughout the plant.

When a change is made in a functional or performance specification, various other types of standards or specifications within the organization may be affected. Up-grading the functional accuracy of a machine unit, for example, may result in changes in:

1. Dimensional or geometrical tolerances for the manufactured components in the unit.
2. Specifications of the materials used for the components.
3. Heat treating or physical specifications for the components.
4. Purchasing specifications if the components are procured from other manufacturers or suppliers.
5. Time standards for machining and assembly operations.
6. Manufacturing and testing procedures and tooling.

Changes in the standards are therefore carefully integrated with other departments, so that all affected departments are able to schedule changes efficiently.

Benefits of Standards: All current specifications are to be found in the Specification Books, which are carefully kept up to date. Depending upon their location, the Specification Books serve various purposes for different departments:

1. *Engineering*—Provide a valuable reference when certain functional design changes are contemplated.
2. *Methods*—May indicate the need for an improved process, better tooling, or a change in fabricating procedures.
3. *Time Standards*—Provide a valuable guide in allotting time for assembly operations.
4. *Manufacturing*—Provide a clear definition of the quality levels that must result from assembly and fabricating operations.
5. *Sales*—Valuable argument settlers in discussions involving performance levels of machines.
6. *Inspection*—Act as foundation blocks for evaluating the company's products and provide accurate yardsticks for measuring their acceptability.

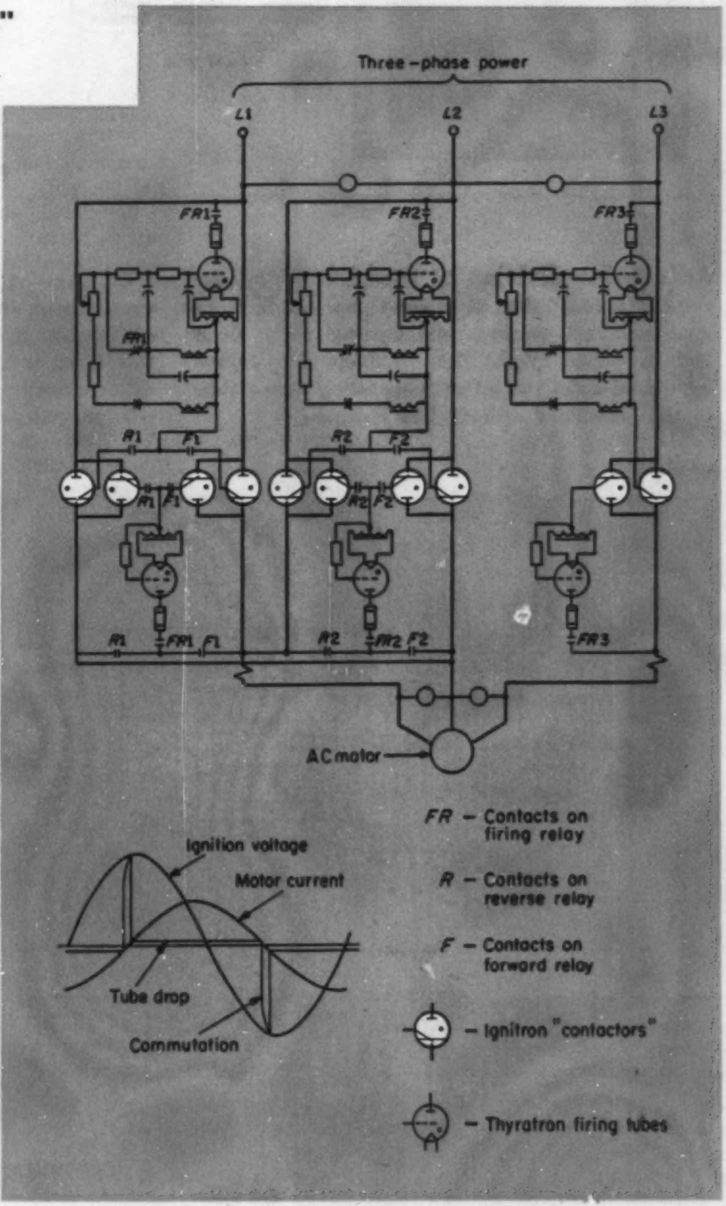
To the company as a whole, performance standards have filled a long-felt need. They have increased co-operation throughout the organization by eliminating technical controversies. They have helped to stimulate the general interest of employees in the quality of products they build. Finally, they have helped to insure a maximum quality of machine performance for the customer. Although the performance specification system at Warner & Swasey is fairly new, it has already paid substantial dividends.

Whenever maintenance of a high product quality level is essential, a custom-built performance-standards system can be an important aid and control.

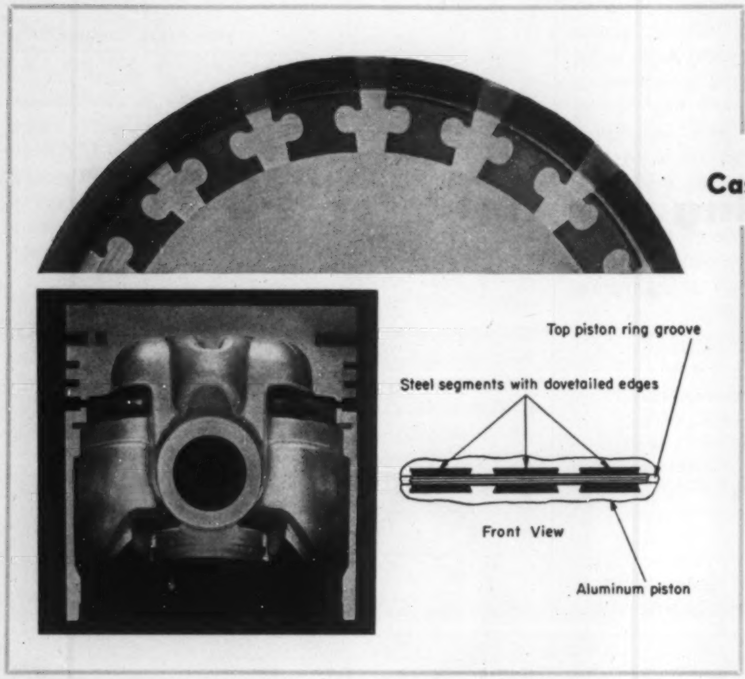
scanning the field for *ideas*

Electron-tube "contactors" in controllers for electric-motor drives eliminate problems of contact erosion, and reduce thermal and mechanical stresses in both motor and load. In a motor-control circuit for draw-press drives designed by D. L. Pettit and R. Montross of the Square D Co., ignitrons (mercury-pool rectifiers) are used to perform the switching function of electromechanical contactors. Cushioned motor starting is provided by the ignitrons' "phaseback" characteristic, which permits reducing their output voltage by retarding their firing angle. Phaseback action with slope control allows motor terminal voltage to build up to a nominal value in a few cycles, with a negligible increase in starting time.

In the circuit design, each phase employs two ignitrons connected back to back (to pass alternating current); another pair of motor-reversing ignitrons is also connected back to back on each of two power lines. Thyratrons are used to control the firing of igniters in the ignitron tubes. Operation is obtained by closing the firing-relay contacts, plus either the forward relay contacts or the reverse relay contacts.


Three-phase power
L1
L2
L3
FR1
FR2
FR3
R1
F1
R2
F2
FR1
FR2
FR3
AC motor
Ignition voltage
Motor current
Tube drop
Commutation
FR – Contacts on firing relay
R – Contacts on reverse relay
F – Contacts on forward relay
– Ignitron "contactors"
– Thyratron firing tubes

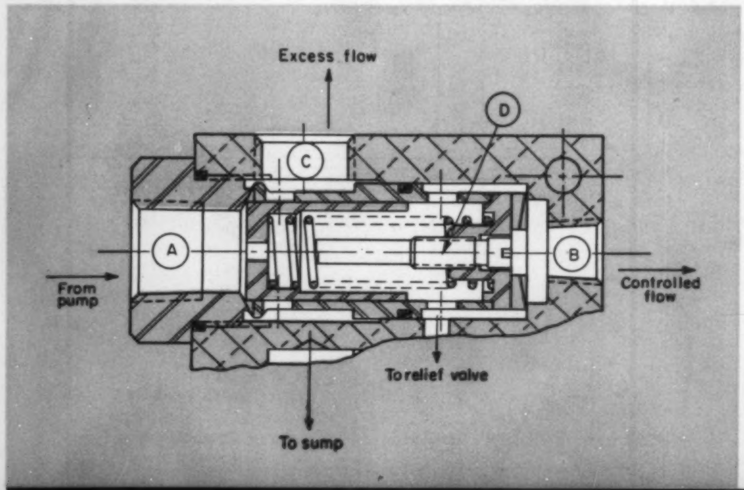
ideas

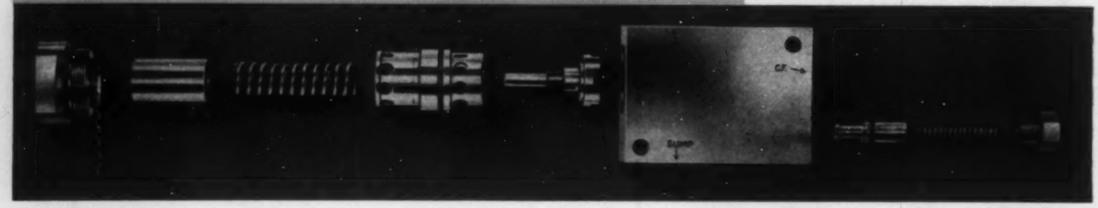

Top piston ring groove
Steel segments with dovetailed edges
Front View
Aluminum piston

Cast-in-place steel segments in top ring grooves of Zollner aluminum pistons provide high wear resistance with cool operation. In this design, individual steel segments eliminate the expansion problem of a continuous band. The steel segments, which provide 75 per cent of the bearing surface area, are designed to prevent radial movement, and the dovetail edges keep the wear surfaces of the segments in alignment with the groove surfaces.

Adjustable division of liquid flow in any ratio is accomplished in a novel flow divider construction that employs one moving part. In a unit developed by the New Products Corp., pressure build-up of the primary operation causes flow to the secondary operation to decrease.

In operation, pump flow enters port *A* where it encounters a spring-loaded plunger with a calibrated hole. A given amount of liquid passes through this hole, on through the valve, and out port *B* as "controlled flow." As pressure builds up at port *A*, the plunger is actuated, allowing the excess oil to flow through other channels to port *C*. When pressure at port *C* builds up, the plunger is actuated farther in an attempt to maintain constant flow at port *B*. However, as the plunger moves in, it encounters an adjustable restrictor screw that partially closes the calibrated hole restricting flow further. Adjustment of the restrictor screw permits reduction of output flow over a range of 10 to 95 per cent of input.


Excess flow
D
C
A
B
From pump
Controlled flow
To relief valve
To sump



Right of Invention

A basic rule of patent law is that patent rights belong to the first inventor. But when there is more than one inventor, who is "first"? Here's how the courts have solved this problem.

By Albert Woodruff Gray
Forest Hills, New York

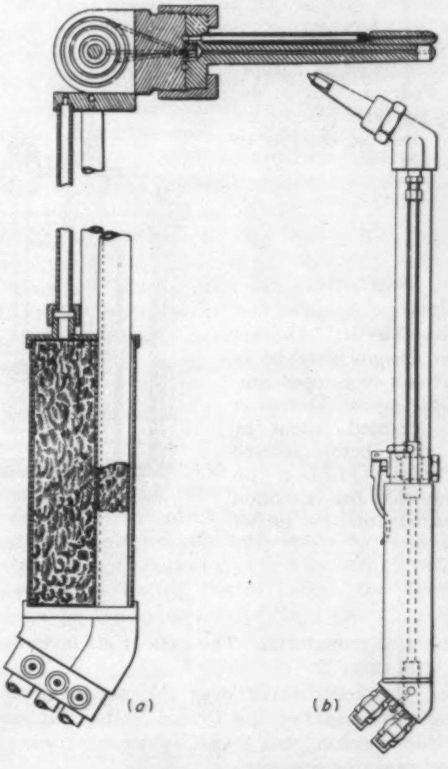
IN THE former patent statute, Congress posed a knotty problem for the courts. The old law provided that in any action for infringement the infringer, in his defense, could show of the patentee, "That he was not the original and first inventor or discoverer of any material or substantial part of the thing patented." The question left for the courts to resolve: Who is the first inventor?

Before the Federal Court of Appeals for decision a few months ago was a controversy over the validity of a patent. The patent, it was contended in this action, had been anticipated by others in the disclosures made in the claims of earlier patent applications. In sustaining this contention, the federal appellate court rested its conclusion on the famous decision by the Supreme Court[1] that has apparently for all time disposed of doubt on such questions.

First Inventor: That fateful case was an action for the infringement of a patent of an oxyacetylene welding torch. From the claims in his patent application, however, the inventor had omitted the process, claiming a patent only on the welding torch itself. In the decision by the District Court, which was later affirmed by the United States Circuit Court of Appeals, it had been said,

"The claims alone give any scope to the invention and some scope is essential to its value. It would seem that the 'invention' must lie in the act of selecting out of the possible combinations which will read upon the disclosure, such as are new and unusual. Therefore the invention must be found in the claims and in the claims alone."

As a consequence of this decision, an omission from the claims in any patent application would leave the features so omitted unprotected by the patent statute and the prey to whomever might seize upon them.

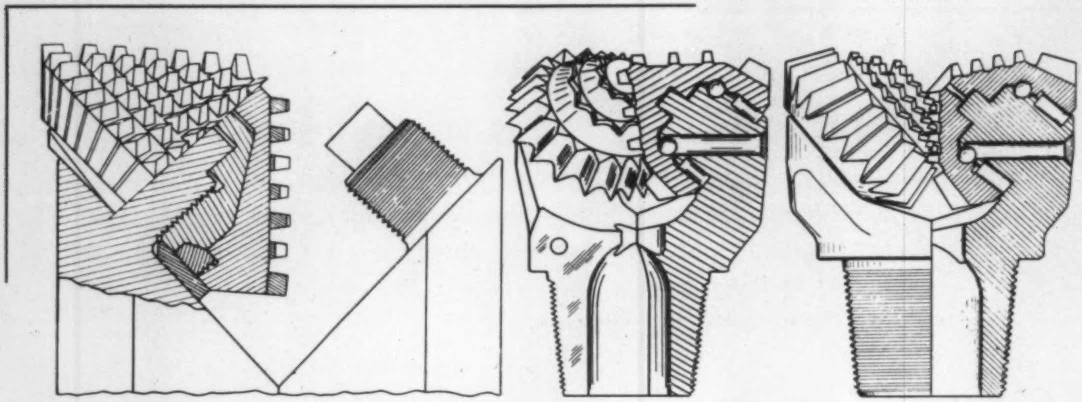


Similar welding-torch patents that were subject of an infringement action brought before the United States Supreme Court. Patent at *a*, which was filed first, contained a description of torch construction in claims but omitted details of operating process. Later patent, *b*, on which charge of infringement rested, claimed process but was declared invalid by the court.

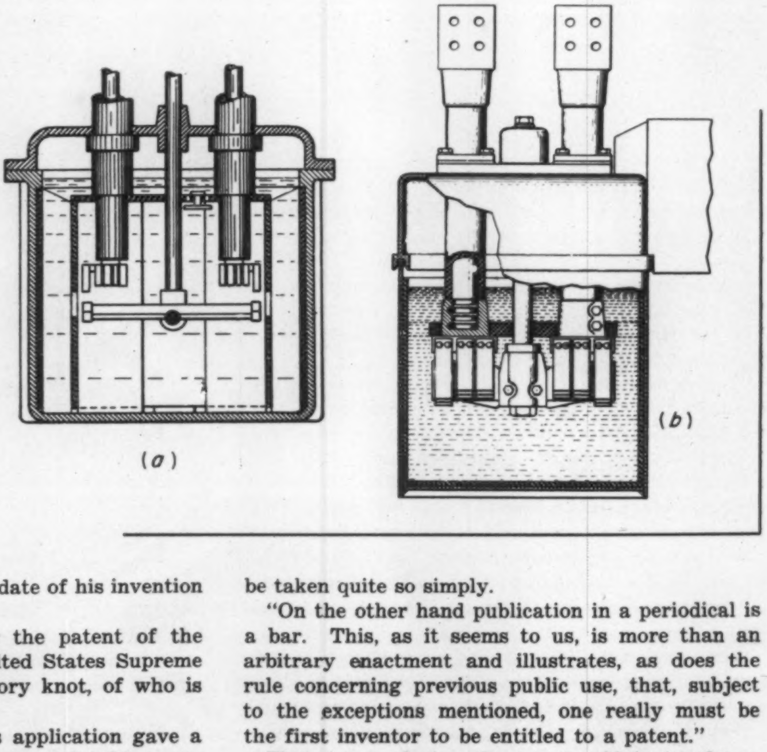
However, in another earlier infringement action before a federal appellate court in Ohio[2], a somewhat different viewpoint had been taken, "Where the tendered issue is whether the patentee is the first inventor and it appears that another had made the invention, the date of that other's patent, or whether the prior description was by printing or

---

[1] References are tabulated at end of article.



Above—Oil-well drill-bit patents cited as authority by Federal court in declaring six later patents on similar drill-bit designs to be invalid.



Right—Electric circuit breaker designs involved in a court suit to compel issuance of a patent. Design at *a* was granted patent by court after being refused by Patent Office on grounds that the invention was anticipated by earlier patent, *b*.

without it, is immaterial. The date of his invention is the vital thing."

When the controversy over the patent of the welding torch reached the United States Supreme Court for decision, this statutory knot, of who is the first inventor, was cut.

"It is not disputed that this application gave a complete and adequate description of the thing patented, but it did not claim it. The patent law authorizes a person who has invented an improvement like the present, 'not known or used by others in this country before his invention,' to obtain a patent for it. Among the defenses to a suit for infringement the fourth specified by the statute is that the patentee 'was not the original and first inventor or discoverer of any material or substantial part of the thing patented.'

"Taking these words in their natural sense as they would be read by the common man, obviously one is not the first inventor if, as was the case here, somebody else has made a complete and adequate description of the thing claimed before the earliest moment to which the alleged inventor can carry his invention back. But the words cannot be taken quite so simply.

"On the other hand publication in a periodical is a bar. This, as it seems to us, is more than an arbitrary enactment and illustrates, as does the rule concerning previous public use, that, subject to the exceptions mentioned, one really must be the first inventor to be entitled to a patent."

Then in conclusion the court said in its determination of the controversy over the definition of these words, "The fundamental rule, we repeat, is that the patentee must be the first inventor."

When the traditional defense was made in a recent action brought for the infringement of patents on oilwell drills, this rule, that the patentee must be the first inventor, served as the authority for the determination of the action[3].

"The rule to be applied in a contest between two or more rival inventors whose applications for patent are pending at the same time is that the one who first conceived the invention and exercised reasonable diligence in perfecting it and reducing it to practice, is the first inventor."

Omission of Details: When details of a description are omitted from the claims or specifications of a patent application, the premise that the patentee must be the first discoverer clears away the fog of uncertainty that had previously clouded this feature of the law.

In a patent application for a vulcanizing process for rubber or latex, an inventor omitted the disclosure of two steps in the process: drying and then vulcanizing. Four years later these two features were seized upon as inventions for which a patent was issued. Of the absence here of patentable features the federal court said[4],

"It would seem to be obvious to any chemist endowed with a reasonable knowledge of the art of vulcanizing rubber, that the cold vulcanizing process, well known in its application to dry rubber, could always be applied in a process of vulcanizing latex."

Then, of the effect of this omission by the first inventor on a subsequent patent application for the same process in which these omitted features were specified, the court added, "The failure of the earlier inventor to claim this invention can make no difference, if he disclosed the invention in his application, as he did."

It has been held further that such disclosures in prior patent applications, to be an anticipation of a later application, need not be set out in minute detail. In a suit to compel the issuance of a patent relating to an oil circuit breaker, described generally in an earlier patent, the federal court said[5],

"This court is not unmindful of the rule that a patentee need not describe in minutest detail, make experiments and accompany his descriptions with sketches and drawings in order that his disclosure may be an anticipation, yet the rule is also clear that before a disclosure can be held to be an anticipation, its language and claims must be so certain and descriptive that one skilled in the art or one who has ben termed a journeyman or an artisan can visualize therefrom, specifically, definitely and in detail, the type of device or construction that was in the mind of the patentee who described it.

"Would a man who was grappling with the problem solved by the patent attacked, and having no knowledge of that patent, if he had had the alleged anticipation in his mind, have said, 'That gives me what I wish'?

"While a simple improvement on a patent would not, as a rule, entitle an applicant to a patent on such improvement, an improvement arrived at on a different theory, producing definitely different results, and resulting in a superior and more useful instrument, must be held to be the result of inventive genius and is patentable.

"If the patentee by a modification which is so lacking in certainty that it shows he is wandering in an unexplored field, could have barred the issuance of patents to others, recognition and reward for long and laborious effort would have been denied to many inventive genii who have contributed so much to almost every phase of human progress."

Paper Patents: Another consideration in the definitions of the phrase "first inventor" is the anticipation effected by "paper" patents—patents under which the invention has never been manufactured or marketed.

On the ground of anticipation a patent for a device for dividing and measuring lubricants to be discharged to various machine bearings was held invalid by a Federal District Court. A foreign patent had been issued over two years before for a similar device which had never been commercially exploited and had apparently remained inoperative without substantial modification. In reversing the decision of the District Court, the United States appelate court said[6],

"We have no doubt that paper patents which precisely disclose the purpose, means and mechanism for accomplishing the end of a patent in suit, or which may be adapted for that purpose by obvious and common mechanical expedients, may be regarded as anticipatory in that they disclose lack of novelty in an assailed invention. But an organization that was neither conceived nor disclosed by the prior inventor, nor adapted by obvious and well-known mechanical expedients, will not convert a prior patent into an anticipation.

"The fact that a prior art device, even though adaptable, was not in fact adapted, strongly indicates that the changes were not obvious and involve more than mechanical skill."

Statute Revision: In 1952, when the present patent law became effective, there was incorporated a new provision based on the earlier Supreme Court decision. In the present statute[7] it is now provided, "A person shall be entitled to a patent unless . . . the invention was described in a patent granted on an application for a patent by another, filed in the United States before the invention thereof by the applicant for the patent."

REFERENCES

1. Davis-Bournonville Co. v. Alexander Milburn Co., 270 *U.S.* 390, March 8, 1926, New York.
2. Lemley v. Dobson-Evans Co., 243 *Fed.* 391, Ohio, June 5, 1917.
3. Chicago Pneumatic Tool Co. v. Hughes Tool Co., 192 *Fed.* 2d 620, Oklahoma, November 12, 1951.
4. United States Rubber Co. v. Sidney Blumenthal & Co., 98 *Fed.* 2d 767, New York, August 4, 1938.
5. Nye v. Coe, 44 *F. S.* 582, D.C., April 13, 1942.
6. Trabon Engineering Corp. v. Dirkes, 136 *Fed. 2d* 24, Michigan, June 4, 1943.
7. 35 *U.S.C.A.*, Sec. 102.

They Say . . .

"However, in America, we mechanical engineers working with our foremen and labor have achieved a system whereby the products of our factories are actually available to all the people, in contrast to the situation in Russia where the factory products are theoretically available to all but actually are unobtainable. This situation not only sets us apart from the Russians but is something of which we mechanical engineers in the United States can be truly proud."—WILLIAM A. HADLEY, *director, Research and Engineering Div., Mergenthaler Linotype Co., Brooklyn, N. Y.*

External blower motor
RESISTOR ACCESS DOOR
FOR MOTOR SERVICE REMOVE THIS COVER AND FAN

Thermal Design in

A practical design guide on

- The thermal design problem
- Electronic equipment thermal-design objectives
- Procedures for minimizing heat generated by electrical and electronic components
- Techniques for isolating heat from sensitive electronic components
- Methods of removing heat efficiently from electronic equipment

DESIGNING electronic equipment for survival in severe thermal environments is a difficult problem that has taken on increased importance in recent years. All electronic equipment and their circuitry are sensitive to extremes in temperature. As equipment is required to operate at increasingly higher or lower temperatures, more attention must be paid to the associated thermal problems, such as imposed on airborne units, Fig. 1. Of course thermal design problems vary with the type of equipment and with the severity of the environment in which it is used. They may be only a nuisance, or they may critically influence performance and life. The severity is relative and the principles of good thermal design are appropriate to the simple cases as well as the severe ones.

Severe thermal environments make it difficult or even impossible to operate the equipment without subjecting some of the circuit components to excessively high temperatures. These high component temperatures, in turn, result in performance degradation and in accelerated failure. Equipments that function adequately at one temperature level will be less reliable or even inoperable as temperatures increase. Figs. 2 and 3 illustrate the sensitive relationship between failure rate and thermal environment for three typical circuit components. Naturally, a similar though composite relationship holds for the circuits in which these components are used. These curves show that reliability is not solely a matter of avoiding the excessive temperatures to which the failure rates are asymptotic. Reduction in temperatures at any range, short of frigid, is reflected by a lower failure rate. Since these component failure rates are additive in computing the circuit failure rate, it is also apparent that the cumulative effect of

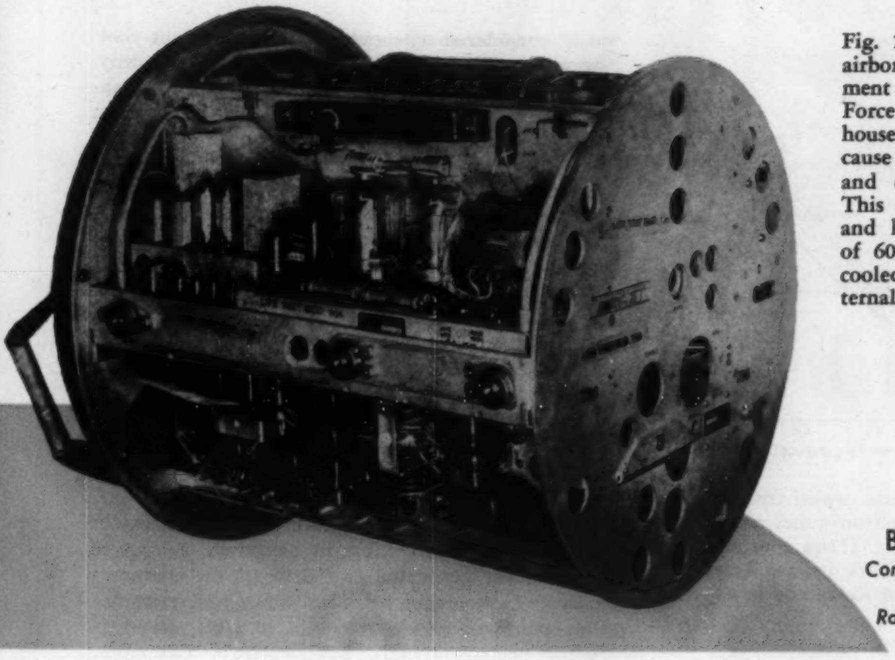


Fig. 1 — The AN/ARC-21, an airborne communications equipment used currently in U. S. Air Force bombers. Equipment is housed in a pressurized case because of the problems of arc-over and cooling at high altitudes. This unit is 18 in. in diameter and has an average dissipation of 600 watts. The equipment is cooled with both internal and external blowers.

By Thomas C. Reeves
Components Application Review
Defense Electronic Products
Radio Corporation of America
Camden, N. J.

Electronic Equipment

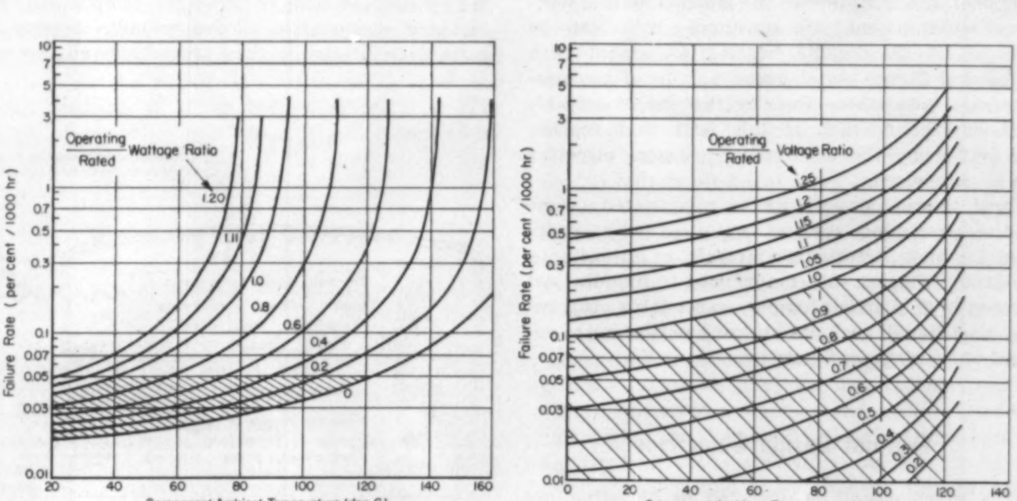


Fig. 2—The effect of local ambient temperature on failure rates for MIL-R-10509A film resistors, left, and MIL-C-25A paper capacitors, right. These failure-rate values are the best approximation of the reliability characteristics, based on random failures, of these components when used repeatedly in complex electronic equipment. Recommended regions for reliable usage are shaded.

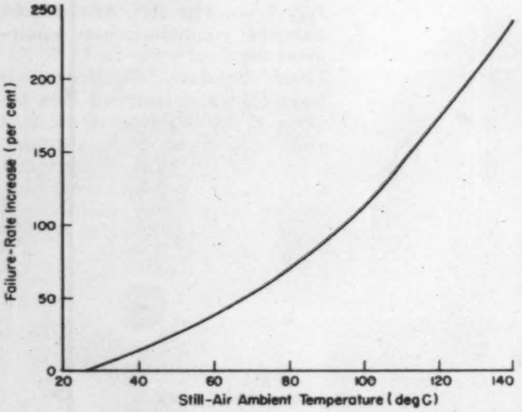


Fig. 3—Plot of approximate sensitivity of failure rate of receiving type electron tubes versus temperature of ambient still air. (Data courtesy M. P. Feyerherm, "Prediction of Tube Failure Rate Variations," *IRE Transactions on Reliability and Quality Control*, January, 1957.)

many minor thermal improvements will equal that of a few major ones. Conversely, it is also obvious that in attention to a majority of minor points in thermal design may compromise good treatment of a minority of major points. Thermal design must be across the board. Every little bit helps.

For a given circuit, reliability depends almost entirely on the thermal environment. Fortunately, however, it is practical to control the local thermal environment of an equipment despite general inability of the designer to do much about the external environment. For instance, little can be done about the kinetic heating associated with high-speed flight; the thermodynamics of the situation are inexorable. But, by the use of suitable methods, the amount of this heat that reaches and is felt by the electronic equipment circuitry can be minimized.

Good thermal design can be complicated. Some of the air-cooling systems employed with equipment for high-performance aircraft, as an example, are fairly complex. Other advanced techniques, not covered in this article, employ expendable evaporative and liquid coolants in conjunction with unusual packaging configurations.

Thermal Design Objectives

If a given circuit is operated in its actual-use environment and some or all of the components overheat to a degree that performance and/or failure rate becomes intolerable, what is the procedure to improve thermal design? First of all, if the use environment, which is too hot, must be accepted as inevitable and unchangeable, the designer could insist on temperature-resistant components that *will* operate reliably in such an environment. This "brute-force" approach is seriously considered whenever local-environment cooling is impractical or penalizes the design heavily. Obviously, though, the upper range of this approach is often quite limited. Inevitably, when thermal limits are reached, additional cooling capacity, at whatever penalty in terms of size, weight, etc., is the only "practical" approach to survival.

Since all electronic components fail or are unreliable at some extreme temperature, means must be adopted to keep component temperatures compatible with the desired reliability. Consequently, the general thermal design problem is: "What can be done to reduce component temperatures?" Common sense will suggest three approaches or objectives to strive for in good thermal design in electronic equipment: (1) Minimize heat generation, (2) Isolate heat from sensitive components, and (3) Efficiently remove heat developed.

Minimizing Heat Generation: In most cases, the heat that causes trouble in electronic equipment is internally generated as I^2R losses in "thermally active" components, such as tubes and resistors. Component temperature rise is, in fact, almost directly proportional to this wattage dissipation. Hence, as dissipation is reduced, component temperature is lowered. This is the common-sense reasoning behind temperature derating of components. Although the wattage problem is obviously electrical, it has heavy thermal overtones. Certainly, the design of efficient circuitry from a heat-dissipation standpoint is an important consideration in good thermal design.

Isolating Heat from Sensitive Components: Sometimes components run excessively hot because they are located too close to other hot components. For instance, germanium diodes usually develop so little heat internally, they are considered thermal-

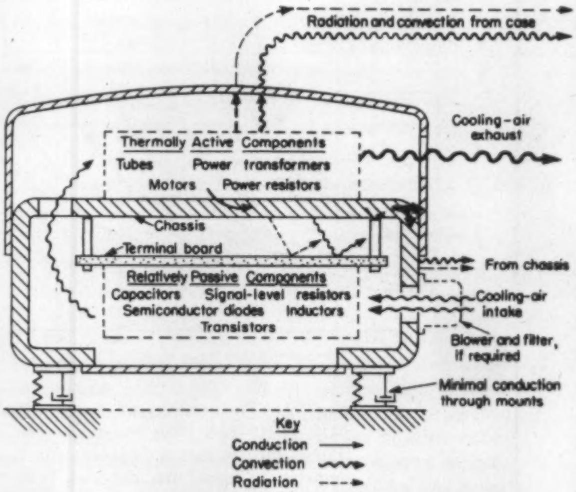


Fig. 4—Heat transfer within a conventional air-cooled electronic equipment by the three possible modes—conduction, convection and radiation.

ly passive, but they are also relatively sensitive to high-temperature environments. Should they be carelessly located adjacent to an underrated electron tube, failure could result. All electronic components are more or less temperature sensitive; it is usually necessary to protect the relatively sensitive parts from the "active" components or heat sources. Since such segregation obviously involves both physical layout of the circuit and electrical design factors, there may be need for a thermal-electrical design compromise.

Efficiently Removing Heat Developed: Heat flow and temperature are analogous to current and voltage. If the thermal circuit has high conductance, a given heat flow can be maintained by a relatively low temperature gradient. This means that with a given component and dissipation, the higher the overall thermal conductance between the component (heat source) and its surroundings (heat sink) the lower will be the resulting component temperature. This heat transfer occurs in all three of the familiar modes—conduction, convection and radiation, Fig. 4. Sound thermal design exploits good use of each as far as practical.

Basic Formula: Rate of heat loss from a body, Q, is given by $Q = K(\Delta T)$ where K is the overall thermal conductance and (ΔT) is the surface-to-surrounding temperature difference. From this key relationship, which will be recognized as Newton's law of cooling, it is apparent that the first approach to minimizing the heat developed is to keep the body temperature low by reducing wattage dissipation. The second approach of isolating the heat is based on increasing the temperature difference by reducing the temperature of the surroundings rather than by increasing the body temperature. This enables dissipation of increased wattage at the same body temperature or of the same wattage at lower body temperatures. The third, of removing heat efficiently, is aimed at increasing the conductance of the body.

Minimizing Heat Generation

The energy dissipated within an equipment is, in one sense, a measure of the electrical inefficiency of the circuitry; it is input power that is not converted to a useful electromagnetic effect. Where there is a potential thermal problem, it should be a circuit-design objective to improve equipment power utilization. True, the relief to be gained through this approach is limited largely by the state of art in component design, in that the resistances of most circuit components is inherent and not controllable by the circuit designer. For instance, it is not practical to design circuits without resistors, and it is impossible to design them without resistance. Consequently, a certain level of resistive power loss is unavoidable. Then, too, most electron tubes operate with rather substantial and inherent heater-power losses. Ranges of operating temperatures of typical components are shown in Fig. 5.

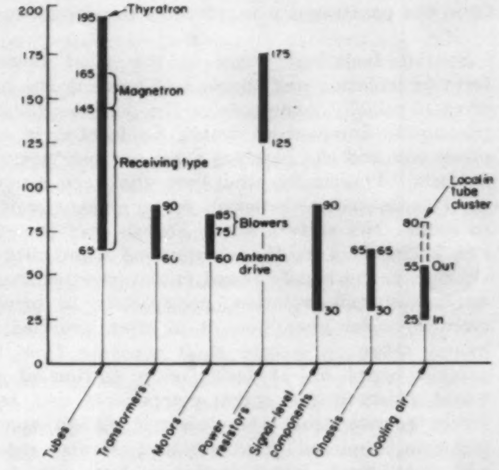


Fig. 5—Temperature levels prevailing in conventional air-cooled electronic equipment at sea level.

The thermal design job will be easier if the circuit dissipation level is the lowest possible consistent with satisfactory electrical performance. Opportunities for designing heat out of the circuits are offered by some of the more recent component developments, such as magnetic amplifiers and transistors. Of course, magnetic amplifiers are transformer-like reactors with variable, signal-controlled core saturation. The ohmic resistance of the device is relatively low and its consideration for low-frequency applications would seem good. The transistor is basically a three-element semiconductor device with signal-controlled output, in many ways analogous to a heaterless vacuum-tube triode. However, although transistors dissipate less heat than tubes, they are quite sensitive to the heat which is dissipated. Their upper thermal limits are typically lower than those of equivalent tubes. Accordingly, piece-meal transistorization, which results in a close intermixture of transistors and tubes, is likely to aggravate rather than relieve the thermal problem. Clearly, there is no panacea here, but care in circuit design can help relieve thermal problems. Designing heat out of a circuit is, indeed, the lightest, most compact, and most efficient way of cooling equipments.

Isolating Heat from Sensitive Components

The design objective of isolation is to attempt to minimize the opportunities for the exchange of heat from the thermally active components, such as tubes, power transformers, motors and power resistors, to the thermally passive components which are usually more sensitive, such as capacitors, signal-level resistors, coils and semiconductor devices. The actual isolation of the actives from the passives can be attained in several ways.

Spatial Isolation: This is the most obvious form of isolation and consists of locating the passives physically remote from the actives. Ideally, the active components would be located in one black box and the passives some distance away in another. Practically, the best that can usually be done in spatial isolation for a given circuit is to mount the actives above chassis and the passive below on a subchassis terminal board, Fig. 4. Obviously, the trend toward miniaturization works against spatial isolation, particularly in printed circuitry. But even here it is often practical to mount tubes on a tube shelf separate from the printed board or, at least, on a section of the board reserved for active components and relatively remote from the passives. When spatial isolation is ignored, proximity heating often results not only from direct radiation but also from higher air ambients and chassis temperatures prevailing in the high-heat-density, active areas. Certainly, the location of capacitors, composition resistors, semiconductor diodes and similar components should not be within point-blank range of electron tubes. Yet instances of this are observable, even to the extent of direct, physical contact. The obvious and cardinal rule for sensible application of temperature-sensitive components is to keep them away from the heat sources.

Radiation Shielding: Although restrictions in overall size often dictate against spatial-isolation design approaches, proximity heating caused by radiation can be overcome by placing shields or partitions between thermally active components and near-by passives. A similar effect results when bright metal envelopes are used for passive components. Effective radiation isolation is based either on the interception of heat radiation, or on the use of low-absorptivity surfaces on the sensitive components.

Conductive Isolation: Occasionally, it is practical to transfer heat by a direct conductive path from the active components to the package exterior by means of thermal shunts. These may range from simple, relatively massive copper strips or braid to more elaborate refrigerant-filled tubes. This technique is seldom employed unless there is a highly localized dissipation that cannot be relocated. When these cooling devices are used, they are true conductive isolators in that they afford protection to the adjacent passive components by diverting relatively high wattages with comparatively low local temperature rises.

Convective Isolation: Control of the coolant path and of component layout can afford still another type of isolation. Where forced-air cooling is employed, the coolant should be directed over the cooler passive components before it reaches the hotter actives. This priority can be established by physical location of the passive components upstream in the coolant flow or, where the layout is not so physically isolated, by the use of coolant plenums and orifices to direct the coolant over the passive components first.

Another very practical technique, which supplements spatial isolation, is to introduce the coolant into a subchassis plenum, in which the passive components are mounted on terminal boards; then route the air through orifices in the chassis and direct it effectively against top-mounted active components, such as tubes. Since passive components do not appreciably raise the coolant temperature, they enjoy the lower more reliable temperatures without jeopardizing the active components downstream. Isolation of this type not only protects sensitive components from the higher coolant temperatures leaving the actives, but it also assures the maximum mean temperature difference for more effective overall heat transfer. In the case of free or natural convection, the effective coolant flow is predominantly ascending and the temperatures increase vertically. Free convective isolation can be achieved best by locating components in appropriate vertical order; the sensitive components mounted in the lower, cooler portion of the ascending flow; active components in the upper.

Removing Heat Developed

After dissipation has been minimized by circuit design and localized by isolation, this heat must still be removed from the equipment as efficiently as possible. This also is done by conduction, convection and radiation.

Conductive Heat Transfer: The basic steady-state relationship governing one-dimensional conductive heat transfer is given by

$$Q = KA\frac{dT}{dx}$$

which can be stated approximately as

$$Q = \frac{KA(\Delta T)}{L}$$

The first equation may be recognized as a simple form of the more general relations derived by Fourier and Laplace, and gives conducted heat as proportional to the material thermal conductivity K, the path cross section A, the path length L, and the temperature gradient $(dT)/(dx)$ or $(\Delta T)/L$. The design objective of maximum heat transfer with a minimum temperature rise is met if $Q/(\Delta T)$ or KA/L is maximized. Accordingly, anything that can be done to increase conductivity and path cross-section or decrease path length helps conduction of heat and reduces source temperatures.

Thermal Conductivity Factor: To increase conductivity, metals that have high thermal conductivity should be used whenever compatible structurally and production-wise. The highest conductivity engineering metals are copper, pure aluminum, aluminum alloys such as 1100, 6063 and 4043, and magnesium alloys, such as M1A, AZ31B, and AZ61A. Reference to the thermal-conductivity tables in metals handbooks will suggest appropriate specific selections.

Thermal conductivities of some common engineering metals are given in Table 1. Since the weight of a conductive feature is important in airborne or mobile equipments, a conductivity-weight factor is included in Table 1 to indicate that metals of high thermal conductivity do not necessarily furnish the highest thermal conduction per pound of conductor.

Effect of Path Length and Cross-Section: Both weight-wise and volume-wise, a reduction in path length is certainly preferable to an increase in path cross-section. For instance, with the same metal and same (ΔT), heat flux can be doubled either by doubling cross-section or by halving path-length. But weight-wise and volume-wise, the latter possibility promises a 4-to-1 advantage. Thermal path length from active source to sink should be minimized by mounting the active components close to the package shell. Such components should not be distributed uniformly about the entire envelope, but rather they should be isolated to an adequate portion of it.

The obvious way to increase path cross-section is to employ generous sections, consistent with strength-weight requirements. This would make aluminum and magnesium alloys preferred choices, especially in the airborne and vehicular-equipment fields. An apparently less appreciated factor in path cross-section is the negating effect of mechanical joints in the path.

Table 1—Thermal Conductivities of Common Engineering Materials

Material	Thermal Conductivity K (watts/sq in./in./deg C)	Density D (lb/in.^{3})	Conductivity-Weight Factor*, K/D
Aluminum, pure	5.5	0.10	55
Aluminum, 6063	5.1	0.10	51
Aluminum, 4043	3.6	0.10	36
Aluminum, 2024	3.0	0.10	30
Copper, beryllium	2.1	0.30	7
Copper, pure	9.7	0.32	30
Magnesium, 99.8% comm. pure sheet	4.0	0.07	57
Magnesium, AZ80A, extruded	1.9	0.07	27
Magnesium, AZ63A, cast	1.9	0.07	27
Monel, sheet	0.7	0.32	2
Silver, pure	10.6	0.38	28
Steel, carbon sheet	1.1	0.28	4
Steel, 18:8 stainless sheet	0.6	0.29	2
Zinc, die-casting alloy	2.9	0.24	12
Phenolic sheet, fabric base	0.008	0.04	0.2

*This factor physically represents the watts/deg C that can be conducted one-dimensionally by a 1-lb slab of material which is 1-in. thick with conduction along the 1-in. dimension. Values listed are typical for the temperature ranges characterizing electronic packaging.

Thermal contact resistance, like electrical contact resistance, is highly sensitive to both the flatness and surface finish of the mating surfaces as well as to the alignment and normal contact pressure. The actual effective metal-to-metal thermal contact area at a mechanical joint may be only a small percentage of the gross contact area; the rest is air gap. As a result, the temperature drop across a mechanical joint may be many times that indicated by the material conductivity and gross contact area alone.

To increase the effective path cross-section at a mechanical joint, reduce air gaps by employing well-finished flats—perhaps slightly concave so as to flatten under contact pressure. Also high contact pressures for thermally "tight" joints should be used. If the contact surfaces are rough, a soft, deformable copper or aluminum foil inserted at the interface will aid in establishing metal-to-metal conformity. A silicone grease, such as DC-4, can perform a similar function in eliminating air gaps due to mating face irregularities. Obviously, a continuous metal-to-metal interface, such as afforded by a welded, brazed or soldered joint is thermally preferable if otherwise practical.

Heat-Conducting Shields: One of the most fruitful applications of conduction is the heat-conducting tube shield; several types are commercially available. This device is effective in more uniformly distributing, and therefore reducing, the normally localized hot-spot temperatures on tube envelopes. In addition to the advantage of more uniform distribution of heat, these shields can also be useful in conducting heat from the tube if the shields are effectively "grounded" to the chassis. Incidentally, avoid the use of conductive tube-shield types whose conductive elements are so rigid that they stress the tube envelope or leads when installed.

Similar conductive devices are available for the thermal grounding of subminiature tubes and certain resistors to the chassis. These devices have been demonstrated to be effective in reducing component hot-spot temperatures, but to be most effective they must be well grounded to a metallic chassis, preferably by soldering. A by-product of the use of these clips is more secure mechanical mounting of the component.

Summing up, conductive heat transfer is encouraged by the employment of short, direct, continuous, massive paths in high-conductivity metals. The path should be continuous from the source to the case shell with all joints in the path designed for low thermal resistance, preferably soldered or brazed. Several proprietary shields and mounts are available for reducing component hot-spot temperatures and for enhancing conduction from the components.

Convective Heat Transfer: The two characteristic types of convective cooling are free or natural, and forced. In free convection, the coolant circulation is gravitationally induced, by differences in coolant density, which in turn result from local heating of the boundary layer of coolant in contact with the surface of the heat source. In forced-convection cooling, on the other hand, the coolant is circulated at much higher velocities by means of pumps or blowers. For electronic equipment, the conventional coolant in both cases is air, although liquid as well as vapor-phase coolants are finding application in certain high heat-flux situations.

The general relationship for convective heat transfer is given by the formula

$$Q = hA(\Delta T)$$

This relationship shows that convected heat Q between the surface and the coolant is proportional to the convection coefficient h, surface area A, and the mean temperature difference (ΔT). The simplicity of this relationship is only superficial. For either free or forced cooling, analytical treatment is relatively complicated, since the convection coefficient is not a constant. It is a function of many factors including coolant density, viscosity, conductivity, specific heat, the geometry and orientation of the heated surfaces in the equipment and the coolant-flow velocity in the case of forced convection. The actual numerical determination of the appropriate convection coefficient for a specific application leans heavily upon empirical data rationalized by the application of dimensionless numbers, characteristically those of Nusselt, Grashof, Prandtl and Reynolds. The complexities of such numerical analysis are beyond the scope of the present simplified discussion of convection.

Forced-Convection Cooling: The rational design of a forced-air cooling system presents some specialized problems centering about the "sizing" of the system. Factors to consider are selection of the physical configuration, the determination of the necessary velocities and mass rates, resultant flow losses or pressure drops through the package and associated ductwork and/or filters, and the selection of a blower. Or, proceeding less analytically, the system size may be based simply on reproducing conditions which adequately handled comparable dissipations in similar packages. A cruder approach is to select a blower arbitrarily and test its performance in the package, changing as necessary. Each technique finds its appropriate applications, but the more severe the thermal environment the more appropriate becomes the rational, analytical approach.

By whatever means the forced-cooling system is actually designed, some generally applicable principles can be outlined. For a given application, the forced-convection coefficient is governed largely by the coolant velocity, higher coefficients being associated with higher velocities. Hence, the attainment of maximum convection with a fixed mass rate infers minimum flow cross-sections. However, this also infers an undesirable maximum pressure drop. An optimum system would obviously embody the best compromise rather than the extreme.

Local geometry is also important. For instance, a staggered tube layout may afford mean convection coefficients 10 per cent to 20 per cent higher than those pertaining to an in-line layout parallel to flow. Tight clusters of tubes should particularly be avoided, not only because of reduced convection but also because of the mutual radiation. The hot-spot temperature of the center tube in a cluster may run 30 C or more above equivalent outer tubes.

The coolant path through the equipment is also quite important. The package should be laid out so that the coolant path travels it uniformly, avoiding structural features, such as sharp turns or obstructions that induce stagnant pockets or "eddies" where the local coolant velocities are ineffective. Obviously, components should be located in the main coolant path, not in corners or immediately downstream of large or hot components. In general, the gross coolant path will be the one of the least resistance between the intake and exhaust, but this is not usually a straight line or of a uniform-velocity profile. Since the sources and sinks of this important path are blowers and vents, these should not be located esthetically or from structural expediency, but rather where they will do the most good.

In many applications, forced-air cooling will increase dust infiltration and may even result in mechanical fouling and/or leakage paths and arc-over. In such cases, air filtration is an obvious resort, as is the employment of forced-draft blowers which maintain the case interior at a slightly positive pressure relative to the surroundings. It is useful to consider the ratio between inlet-exhaust areas and the equipment cross-section; this may suggest the existence of stagnant corner pockets at the inlet expansion or exhaust contraction. Multiple inlets and exhausts can be employed to redistribute the flow and break up such pockets. A structurally flexible mock-up, which permits experimentation in the location of components and coolant path, can be quite an effective aid in firming up a cooling system design. The possibility of subchassis terminal-board cooling should not be ignored and has been mentioned previously under spatial and convective isolation. Terminal boards should, of course, be located and oriented to take advantage of prevalent flow.

Table 2—Free-Convection Heat-Transfer Capability of a 5-inch Cube

Ambient Air Temp. (deg C)	Cube Surface Temp. (deg C)	Cube-to-Air Temp. Diff. (deg C)	Total Convected Heat, Q (watts)	Heat Flux Q/A (watts/sq in.)
25	45	20	11	11/150=0.07
25	65	40	24	24/150=0.16
25	95	70	49	49/150=0.33
25	125	100	74	74/150=0.50

Obviously in designing for forced-air cooling, care should be taken to see that the coolant supply is grossly adequate and further that it is efficiently utilized by planned distribution to each sensitive component.

Free-Convection Cooling: This mode of cooling is adequate for many sea-level equipments where the dissipation levels are moderate. One arbitrary but common rule-of-thumb is that forced-air cooling is not required so long as the heat flux (total dissipation divided by total case surface area) is less than ¼ to ½-watt per square inch. The higher limit would apply to well-vented cases where the components are well-mounted from a conduction standpoint. The lower limit applies to unvented cases of conventional construction. Obviously, many black boxes fall under these limits and free-convection cooling is far from being an obsolete technique.

At this point it is pertinent to seek some idea of the order of magnitude of the free-convection cooling contribution. Table 2 gives data on the free-convection capability of a 5-inch cube at various surface temperatures in 25 C still air at sea-level; radiation is not included in Table 2. If this cube were hollow and used as an equipment package with the components *uniformly* distributed in *good* thermal contact with the faces, the component temperature would correspond *roughly* to the surface temperatures cited. The point here is that free convection sustains fairly high values of heat flux at reasonable temperature differences.

Free-convection coolant velocities are so low that often the normal air movements encountered in an occupied room or certainly outside even in a slight breeze furnish valuable assistance. Thus, an equipment is best cooled naturally if it has no case. Although this is usually impractical, it suggests ventilating the case as much as possible with louvers, vents, screens or even open panels.

If the case must be sealed or left unvented, the free-convection capability is reduced consider-

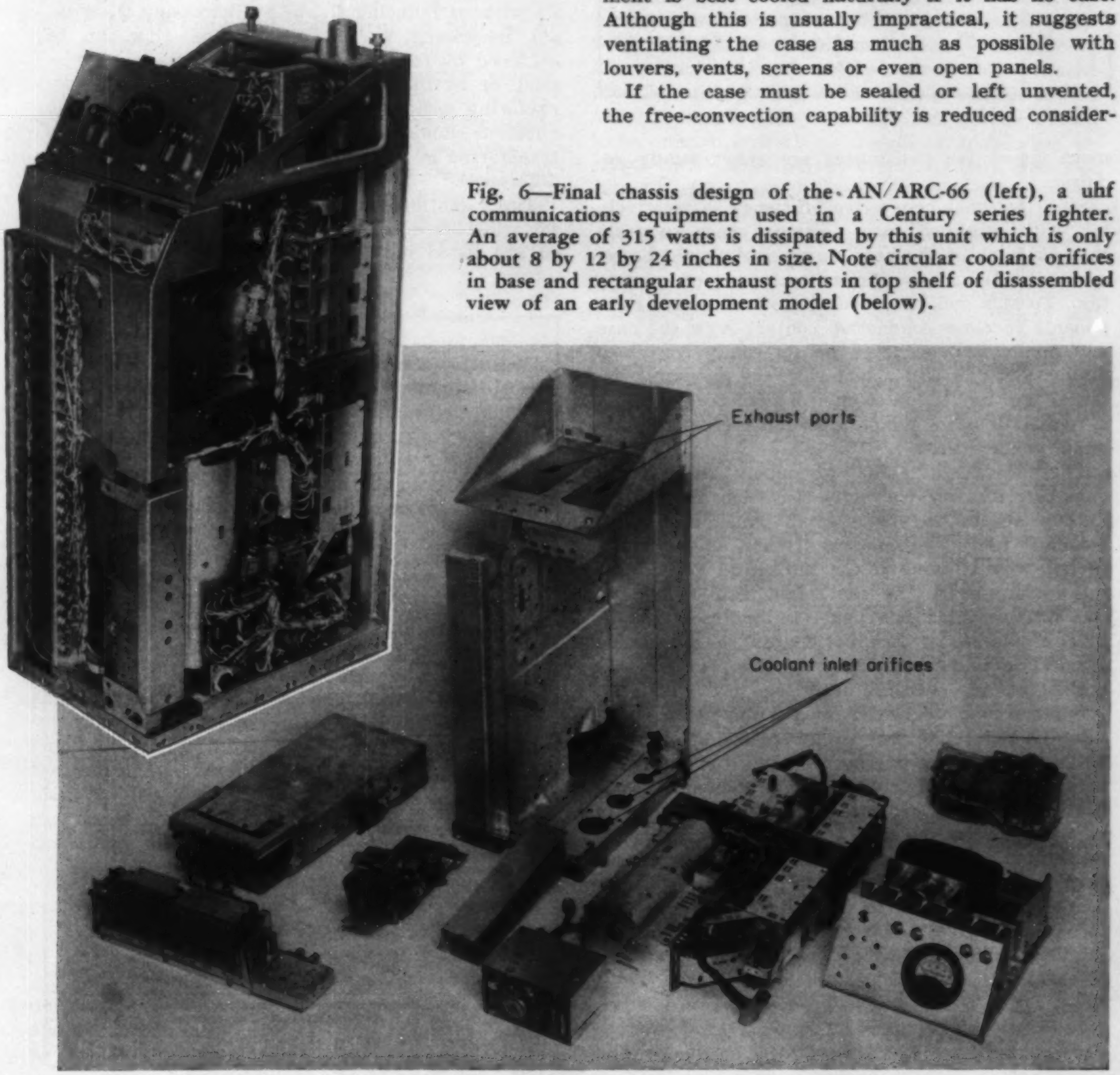


Fig. 6—Final chassis design of the AN/ARC-66 (left), a uhf communications equipment used in a Century series fighter. An average of 315 watts is dissipated by this unit which is only about 8 by 12 by 24 inches in size. Note circular coolant orifices in base and rectangular exhaust ports in top shelf of disassembled view of an early development model (below).

ably since three convective transfers are usually involved from component to environment. First, the heat is convected from the component to the air inside the case. The air then convects this heat to the inside of the case. Then the heat is conducted through the case. Finally the heat is convected from the case to the environment. Four transfers; three convective resistances in series. Contrast this to what occurs in a partly open or wall-vented case where the convective transfer is largely direct from component to environment, and the internal air-to-case and case-to-environment convective resistances are substantially reduced.

Table 3—Radiant Heat-Transfer Capability of a 5-inch Cube

Ambient Air Temp. (deg C)	Cube Surface Temp. (deg C)	Cube-to-Air Temp. Diff. (deg C)	Total Radiated Heat, Q (watts)	Heat Flux Q/A (watts/sq in.)
25	45	20	13.5	13.5/150=0.09
25	65	40	28.5	28.5/150=0.19
25	95	70	58.5	58.5/150=0.39
25	125	100	96	96/150=0.64

Since internal convective efficiency is relatively low with a sealed case, common sense suggests that as much of the heat as possible should be removed by the more efficient technique of conduction. To this end, the mounting of all active components in close conductive contact with the case will minimize dependence on internally convected dissipation, and will insure that the inevitable external free convection to environment occurs across a relatively large temperature difference at maximum surface area.

The comments made previously on vertical mounting for free convective isolation apply here, too. In general, a single small panel, such as a terminal board, is somewhat more efficient convection-wise if used in the horizontal plane with the surface heated by the components facing up. But if more than one panel is involved, that is, a book or stack of terminal boards, the preferable orientation is vertical, side by side, rather than horizontal, one over the other.

Summarizing, to benefit most from free convection, the convective path to the environment should be as direct as possible by providing for maximum access of the components to environment by ventilation. Sealed or unvented cases should normally be avoided because of the high series resistance introduced by the case. If sealed cases are necessary, active components should be thermally bonded to the case so as to minimize the effect of internal convective inefficiency and to maximize the gradient and surface area available for the external transfer.

Radiant Heat Transfer: The general relation for *net* radiant heat exchange Q_R between two surfaces is given grossly by

$$Q_R = F_c F_e \sigma (T_H^4 - T_c^4) A$$

where F_c is a configuration factor that is controlled by the mutual geometry of the surfaces, F_e is an emissivity factor determined by the respective emissivities of the surfaces, σ is the Stefan-Boltzman constant, and T_H and T_c are the absolute temperatures of the source and the sink, respectively. For the pertinent case where the heated body or surface (equipment case) is radiating to its enclosing environment, A is given as the surface area of the source at T_H. With a given dissipation, it is usually desirable to try to obtain the best radiant contribution without incurring the penalty of higher source temperatures. By rearrangement of the previous equation

$$T_H = \left(\frac{Q_R}{F_c F_e \sigma A} + T_c^4 \right)^{1/4}$$

Accordingly, benefit is realized either by reducing T_H without reducing Q_R, or by increasing Q_R without increasing T_H. In either case, this can be achieved by reducing T_c, which is usually impractical, or by increasing the $F_c F_e A$ product. Before exploring means of increasing $F_c F_e A$, perhaps the question should be asked: how much heat can be transferred by radiation at reasonable temperature differences?

The radiation flux values from the same body for which free convection was previously calculated are listed in Table 3. They are based on the

Table 4—Emissivities of Typical Surfaces at Temperatures Characterizing Electronic Equipments

Surface Materials	Emissivity* (20 to 200 C temp. range)
Metals	
Aluminum, polished	0.05
Aluminum, commercial sheet	0.1
Aluminum, oxidized	0.1 to 0.2
Aluminum, anodized (brown-green to blue-purple)	0.2 to 0.8
Copper, polished	0.03
Copper, oxidized	0.7
Iron, as cast	0.8
Iron, cast and machined	0.3
Steel, polished	0.2 to 0.6
Steel, oxidized	0.6 to 0.9
Steel, 18:8 stainless sheet	0.2
Paints	
Various paints and enamels, all colors	0.8 to 0.9
Snow-white lacquer	0.9
Black, gloss enamel	0.9
Black, flat lacquer	0.95
Lampblack in shellac or waterglass	0.95
Aluminum paints	0.3 to 0.8
Platings	
Chromium, polished	0.08
Zinc, bright electroplate	0.24
Tin, commercial coat	0.08
Nickel, dull	0.11
Miscellaneous	
Glass	0.9
Most nonmetals	0.8 to .95

*The above values represent averages or ranges of values found in standard texts and reference sources.

maximizing assumption that the $F_c F_e$ product is unity. If a comparison is made with the free-convection values shown in Table 2 for the same body and temperatures, the *potential* upper-limit radiation contribution is greater than that contributed by free convection at sea level. Obviously, radiation would be proportionally even more important at higher altitudes where the free-convection capability is reduced. Attention to radiation is well merited, then, and the designer should make the most of it by increasing the F_cF_eA product.

Basically, F_c is a measure of the "look" the source surface gets of the cold receiver surface and of the proportion of the emitted radiation that is intercepted by the receiver surface and radiated back to the source. It is unity for extensive parallel planes and for bodies completely enveloped by the receiver surface. Without touching on the many possible geometric variations, the design objective should be to locate the source and orient its surfaces so that they have the best possible exposure to the receiver surfaces. This applies to the individual component as well as to the black box. The converse is also true; if a component must be kept cool, the designer should prevent it from "seeing" radiation from hot bodies. Of course, that is the reason for shielding sensitive components from heat-radiating sources.

The radiant contribution can also be enhanced by employing high-emissivity surfaces, thereby raising the emissivity factor, F_e. As shown by the data in Table 4, it is possible to increase by as much as a factor of 10 the low-temperature emissivities of many engineering materials simply by the application of higher emissivity finishes.

The relative degree of potential improvement in emissivity is more interesting and dependable than the absolute values listed. There is little relation between visual color and emissivity in the temperature range considered here. For instance, most paint finishes have emissivities between 0.8 and 0.95 regardless of color, and flat white is practically as good as flat black. In general, however, black is a more serviceable and acceptable finish for electronic packages.

Various chemical and electrochemical finishing processes are also effective in increasing low-temperature emissivity, though they apparently are not so effective as flat or crackle black. Note the interesting possibility in the design of equipment that may be subject to solar radiation of employing the differential between the low solar absorptivity of white, which is about 0.3, and its low-temperature emissivity, which is three times that value or 0.9. The radiation equation also shows that more heat can be transferred by increasing the source area A, but this is usually impractical.

Summary Remarks

This article has sketched the three fundamental objectives in thermal design—reduction, isolation and efficient removal of heat. The object has been to develop a design philosophy rather than a check list of design details.

Principles of good thermal design are direct and rational in the qualitative sense. It is usually easy to make improvements in thermal design. The difficulty, from an analytical standpoint, is to predict accurately the amount of improvement and to weigh it against the probable costs. This difficulty arises because of the complexity of the problem and the shortage of data on thermal performance of electronic components.

Equations for heat transfer by conduction, convection and radiation in complex equipment, such as shown in Fig. 6, are so ponderous as to be unsolvable by ordinary means. Only simplifying assumptions can reduce the problem for convenient treatment. Even then much information is lacking concerning the thermal behavior of components. For example, how much they vary from the handy, idealized isothermal cylinders, prisms and plates referred to in the equations. As a result, any design predictions made on the basis of classical heat-transfer analysis are, even when practical, subject to broad tolerances. To narrow this tolerance band, it becomes necessary to complement classical analysis with rather earthy empirical data based on actual performance of equipments with which parallels can be drawn. This amounts to an interpolation or extrapolation based on experience and furnishes a preliminary design that can be developed, tested and modified, if need be. This procedure will assure the designer that the equipment will maintain the temperatures necessary to yield the required level of reliability. Here a final area of uncertainty is encountered. Little is known about the relationship among thermal environment, circuit performance and life. What is know is usually based on component performance under standard, but thermally unrealistic, test conditions. Corrections for the departure of actual equipment conditions from the standard must be introduced.

An enumeration of these limitations paints somewhat of a dark picture of thermal design. Actually, the end results of the process have been satisfactory. Ability to control thermal environment and to predict the level of reliability seems to have been validated by recent field history. The compromise of analytical and empirical design backed up by development testing and modification is not a sophisticated approach. Frankly, it is largely trial and error. But the feedback is effective.

ACKNOWLEDGMENT

Illustrations of airborne equipment in this article are reproduced with the permission of the RCA Airborne Systems Dept., Airborne Communications and Navigation Engineering Section.

BIBLIOGRAPHY

1. *Guide Manual of Cooling Methods for Electronic Equipment*, Navships 900,190, Government Printing Office, Catalog No. D 211.6:EL 2/2.
2. *Heat Transfer in Miniaturized Electronic Equipment*, Navships 900,189, Government Printing Office, Catalog No. D 211.6:EL 2/3.
3. J. Kaye and M. A. Rivas Jr.—*Bibliography on Thermal Effects in Electronic Equipment and in Small Electrical Machines*, RLHTE-9, Research Laboratory of Heat Transfer in Electronics, Report No. M.I.T., Cambridge, Mass.

Synchronizing Motions with

H. L. Stewart and J. M. Moritz
Logansport, Ind.

EQUAL force or equal travel along two or more lines is frequently required of hydraulic-cylinder installations. The degree of synchronization necessary will determine which of many methods will best satisfy the design requirements.

Synchronization, at first glance, does not appear to present any problem. If the fluid power is simply directed to two cylinders of the same bore and stroke, synchronization should be automatic. But it isn't—for several reasons. First, the fluid will follow the path of least resistance. If packing friction, piston fit or rod finish cause greater friction in one cylinder than in the other, the piston in the cylinder with the least internal friction will move ahead. Second, absolute bore size of cylinders is a factor, as are length and size of feed lines. Third, any nonuniformity in loading or other form of external resistance will throw the pistons out of synchronization.

This article presents a summary of ten methods for achieving synchronization from hydraulic cylinders. Three types of methods are available: (1) One cylinder with mechanical transfer of force to two or more lines of action; (2) Two or more cylinders with mechanical control of synchronization; and (3) Two or more cylinders with direct hydraulic control of synchronization.

Generally, mechanical synchronization is the most precise. The various all-hydraulic schemes offer different degrees of synchronization accuracy, according to application conditions and refinement of hydraulic control system.

Mechanical Transfer From One Cylinder

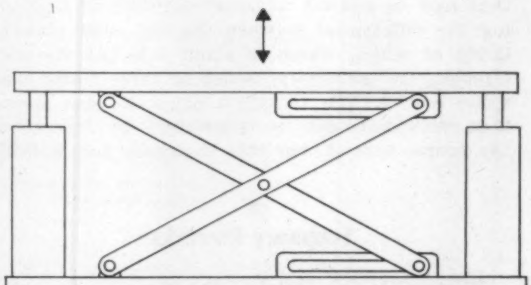
Depending upon the nature of the design, it may be possible to use one large cylinder. A moving ram employing a large cylinder, *a*, should have long bearing surfaces on the slide to assure precision alignment during the stroke. Most hydraulic presses are based upon this general design, many employing bushings sliding on round rods for alignment. A rack and pinion arrangement, *b*, effectively provides equal pressures and travel at four points. Synchronization of movement is provided in both directions. Parallelogram linkages may be operated by a fluid cylinder, *c*, to provide equal pressure and movement at a number of points or over a wide area.

Mechanical Linkage Between Pistons

One of the most positive methods to synchronize cylinders is to tie the pistons together mechanically. This may be accomplished by a rack and pinion arrangement, *a*. Such a linkage provides perfect timing as long as wear and backlash are kept to a minimum. Some applications may permit joining the two piston rods directly together with a single pinion, *b*. Bell cranks, *c*, and similar linkages, permit synchronization of pistons which do not have parallel movement.

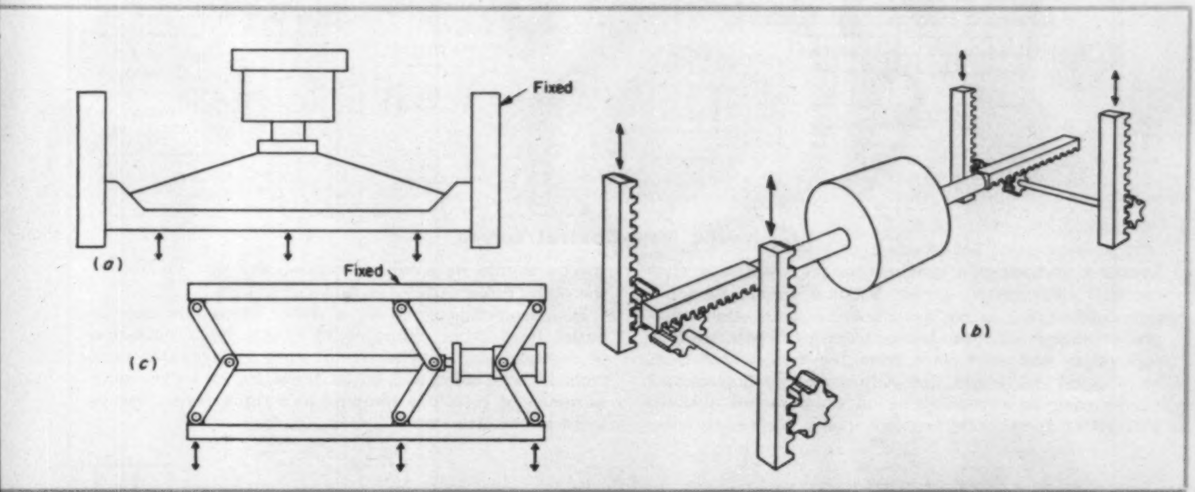
Mechanical Linkage to Moving Member

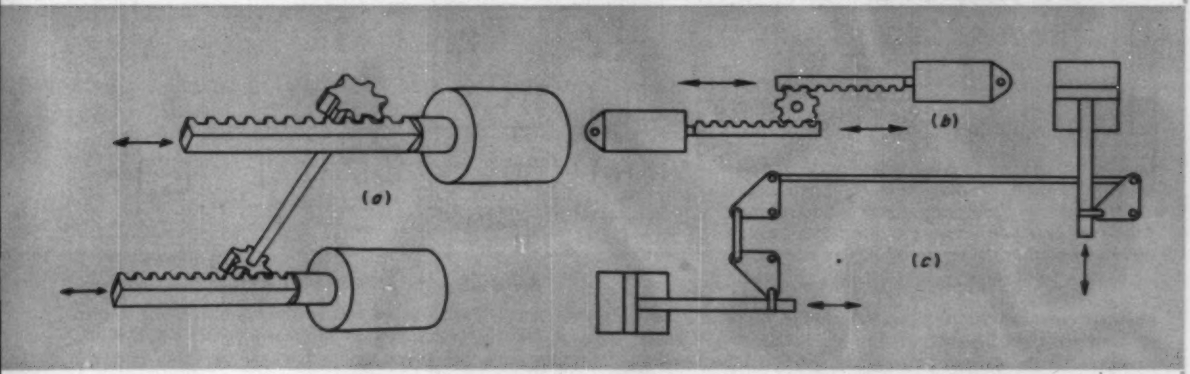
Various devices may be employed to link the moving member to a stationary reference surface so that controlled movement is provided. Familiar mechanical linkages are shown at *a* and *b*. These linkages provide adequate control as long as sufficient rigidity is provided and wear and looseness are kept to a minimum. Most devices of this nature are heavy and require considerable space. In some cases a system of cables, *c*, may be employed. Advantages of the cable arrangement are its lighter weight, lower cost, and simple correction for wear and replacement.

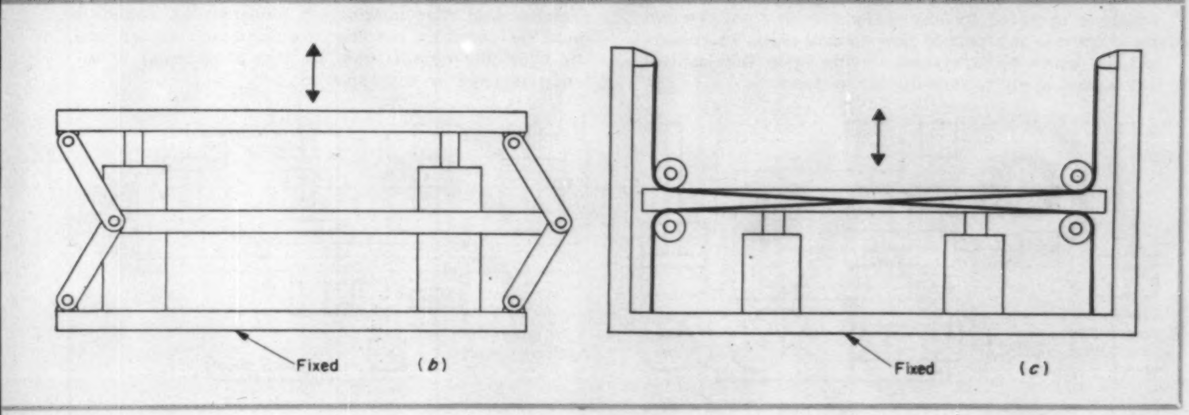


(*a*)

Hydraulic Cylinders

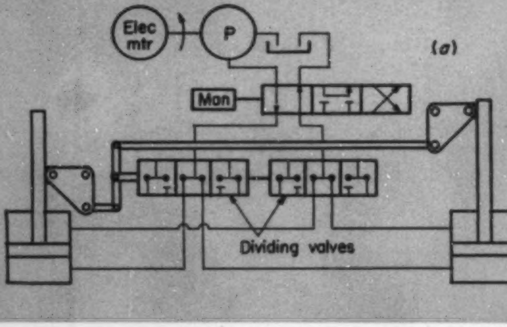

Fixed
(a)
Fixed
(c)
(b)

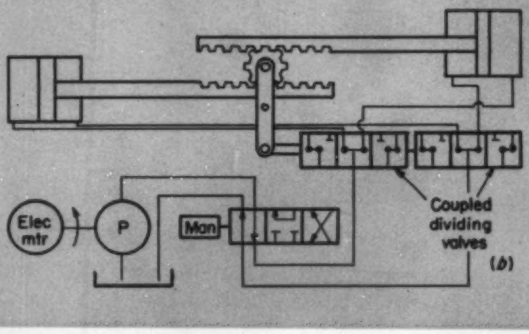



Fixed
(b)
Fixed
(c)

Mechanical Linkage to Flow-Control Valve

Piston rods, or parts moved by piston rods, may be mechanically linked to operate a proportioning or dividing valve. Since the linkages carry very little load, they may be designed for precision operation at relatively low cost. A bell-crank type linkage is shown at *a* and a pinion-operated arrangement at *b*. Dividing-valve systems in which piston movement controls the fluid flow are quite accurate. Inasmuch as the flow is divided according to accumulated error, greater accuracy is provided than in a purely hydraulic system which relies on flow rate alone. Inaccuracies due to variations in friction are eliminated.

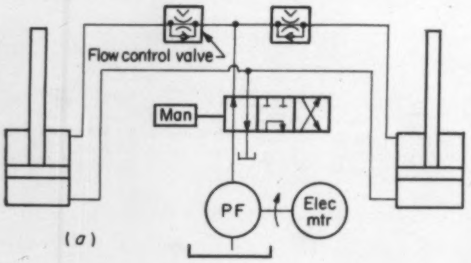


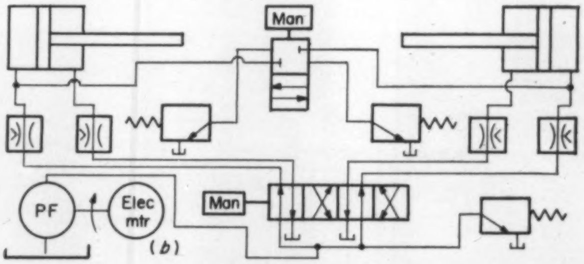


Hydraulic Flow-Control Valves

In many all-hydraulic synchronizing applications, flow controls will suffice. Piston leakage should be minimum although it is not as important as in other flow-proportioning circuits. Lines from cylinders to flow controllers and inlet lines from tee to cylinder must be of equal length and size. Adjustment of flow-control valves may be necessary as oil temperature changes will affect speed of piston movement. Extremely slow speeds should be avoided because any dirt or lint in the oil will clog orifices in flow controllers.

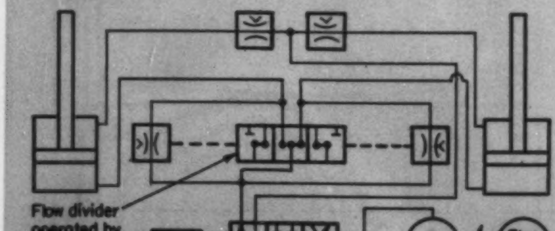
In circuit illustrated at *a*, flow controllers are on outlet lines from cylinders to effect synchronization of forward stroke. The circuit at *b* incorporates controls in both inlet and outlet lines. Relief valves may be included to allow dumping and rapid piston movement in one direction.





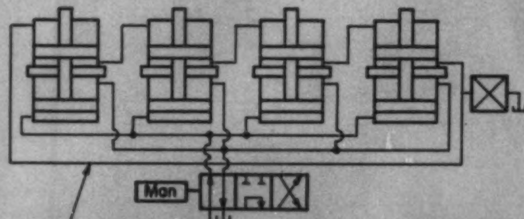
Fluid-Flow Dividers

Approximate synchronization may be achieved by use of flow dividers located in the inlet line, outlet line, or both. A flow divider is essentially a throttling valve which is operated by any difference in flow through fixed orifices of a pair of flow-control units. The observations made for a system relying upon flow-control valves also apply to flow-divider systems.



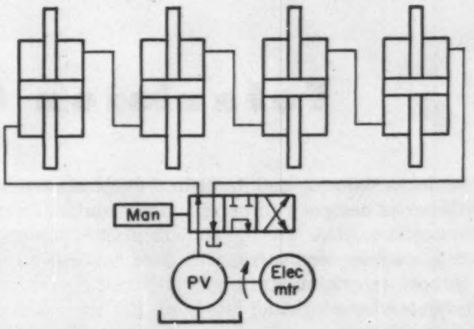
Air-Actuated Hydraulic Series Circuit

Synchronization can be attained with a pneumatic system that is controlled by a closed hydraulic system. When high pressures are not required, such systems perform well. For satisfactory performance, cylinders must be carefully matched for bore and stroke and the hydraulic circuit must be free of external or internal leakage or entrapped air.



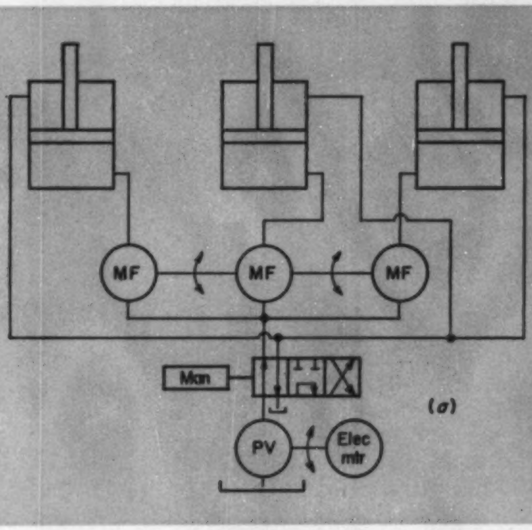
Double-Ended Cylinders in Series

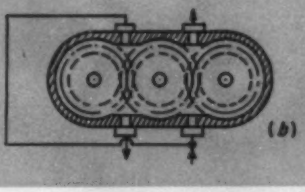
When a number of cylinders are involved, the series system for synchronizing double-ended cylinders offers high inherent accuracy but is subject to mechanical limitations. Due to the extensions on both ends of the cylinders, this method may be impossible due to the space required. Bore and stroke of all cylinders must be identical. Cylinders must be free from both external and internal leakage. If there is any escape of fluid, or air becomes trapped in the line, the cylinders will quickly get out of phase. Series systems require higher operating pressures than those where oil is directed from the pump to each individual cylinder.



Coupled Fluid Motors

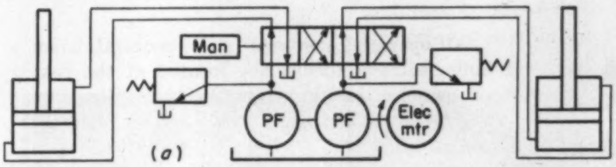
Fluid motors may be used as equalizing or dividing valves to assure equal delivery to two or more cylinder feed lines. A circuit utilizing three coupled pumps is shown at *a*. Such a circuit utilizes standard fluid motors, or pumps used as motors, of the fixed-displacement type. The units are not powered, but are interconnected for metering purposes and free-wheel with the fluid flow. A single unit capable of controlling flow to two cylinders is shown at *b*.

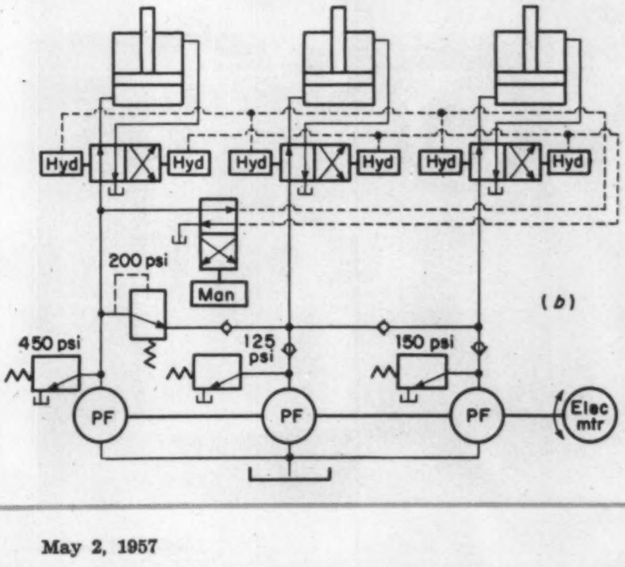


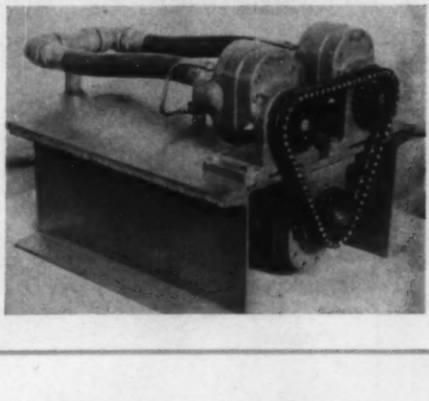


Coupled Pumps

Close synchronization of movement among pistons that have uniform loading may be secured by one motor that drives a number of separate pumps, one for each cylinder, *a*. Cylinders, length and size of lines, and the fixed-displacement pumps must all be matched. The circuit at *b* has a system of relief and check valves which causes one pump to furnish holding power on all three cylinders after they have reached the end of their stroke and pressure has built up within the system.



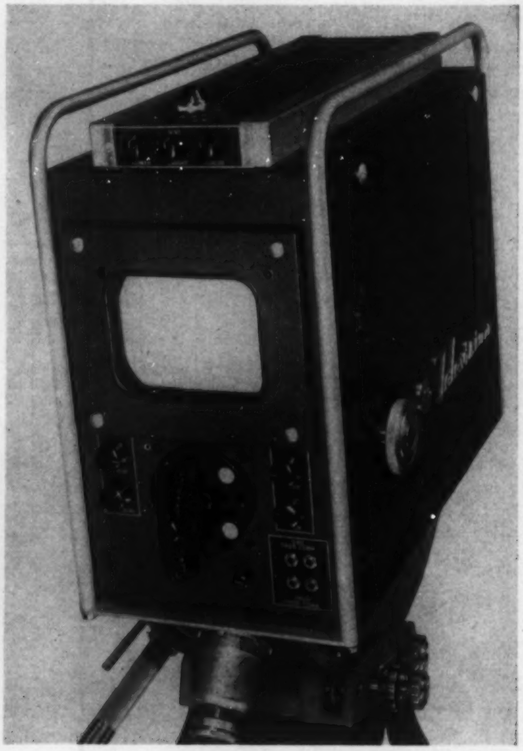




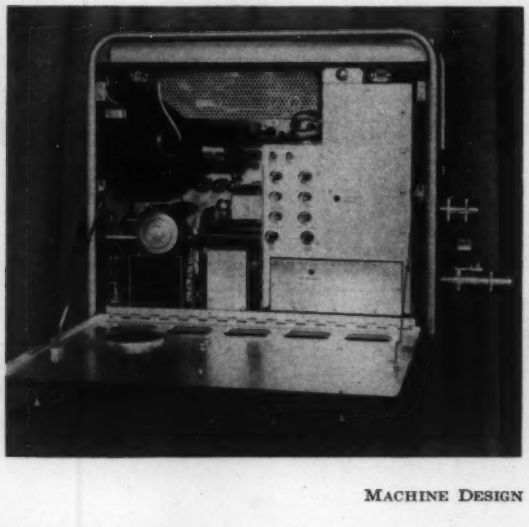
Television Camera Designed for

Television camera and built-in 7-inch electronic viewfinder is designed to permit video control from camera. The RCA TK-15 Vidicon studio camera, which has a four-lens turret, has been developed for use in both television stations and closed-circuit installations where lighting levels of 200 footcandles can be maintained. Usable pictures can be obtained with 50 footcandles or less. Mechanically, the camera is designed for rugged use and easy accessibility to components. Electrically, circuit-design techniques have been used to reduce tube complement without affecting performance. Feedback-stabilized circuitry simplifies camera setup and operation.

Television

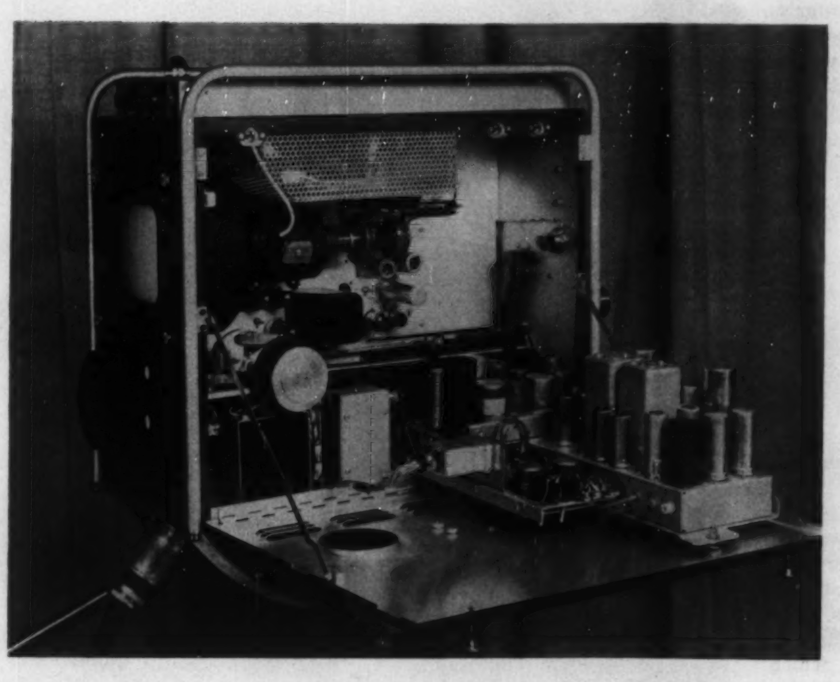


All operating controls (gain, pedestal, beam and electrical focus) are located at the rear of camera, easily accessible to cameraman. Electrical adjustments can also be remotely controlled.

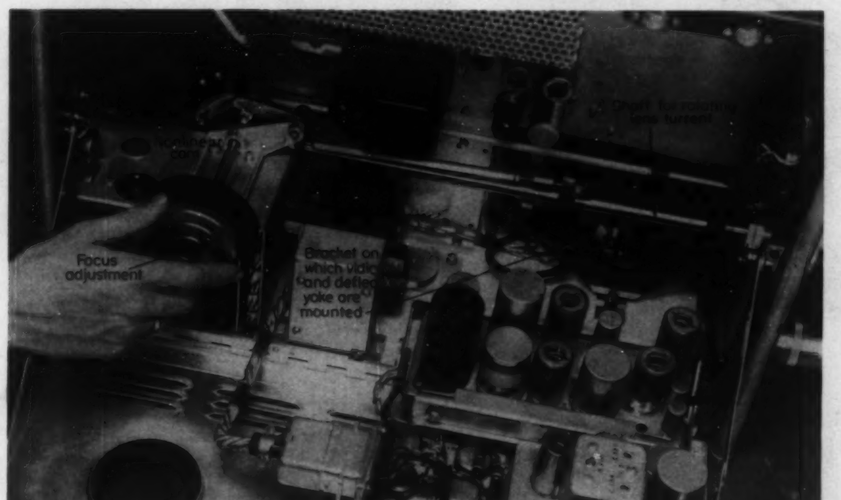


Hinged-door design on both sides of camera exposes the interior completely for inspection and maintenance.

Easy Control and Maintenance



Video amplifying circuits are mounted on a hinged subchassis that swings outward from the camera, providing easy access to every component. The video preamplifier circuits are contained on a separate shock-mounted subchassis.

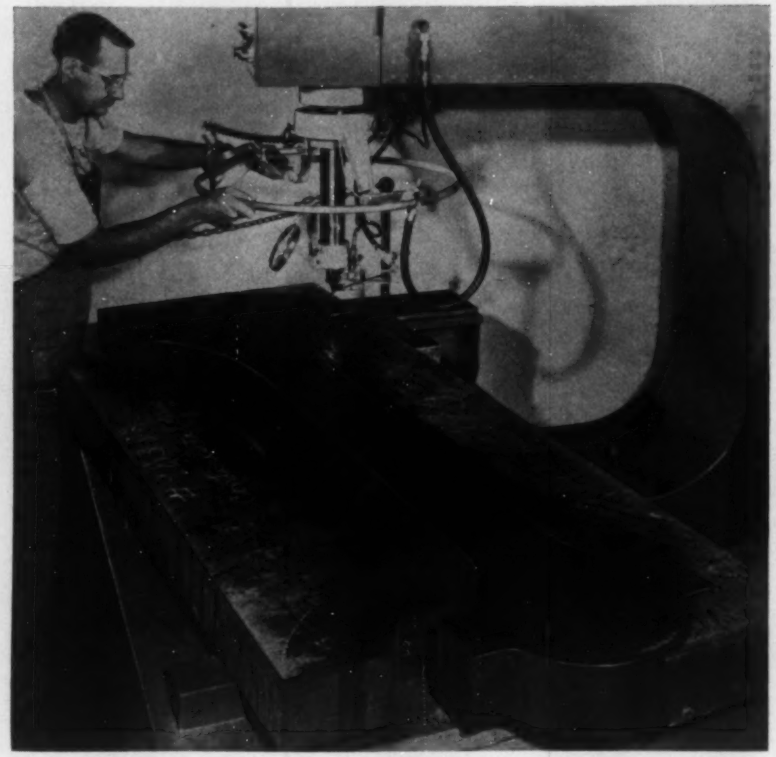

Nonlinear cam
Shaft for rotating lens turrent
Focus adjustment
Bracket on
which vidic
and deflec
yoke are
mounted

Nonlinear optical-focus mechanism provides, without backlash, close-tolerance focusing required in the Vidicon (camera picture pickup tube). The Vidicon and its deflection yoke are mounted on a bracket that rides on the shaft for rotating lens-turret and are thus maintained accurately in alignment with the lens in use. In focusing the camera, the bracket is moved forward or backward on the lens-turret shaft by a nonlinear cam that compensates for changes in rate of focus travel required at various distances of the camera from the televised scene. Amount of knob rotation required to focus the camera is essentially independent of object distance.

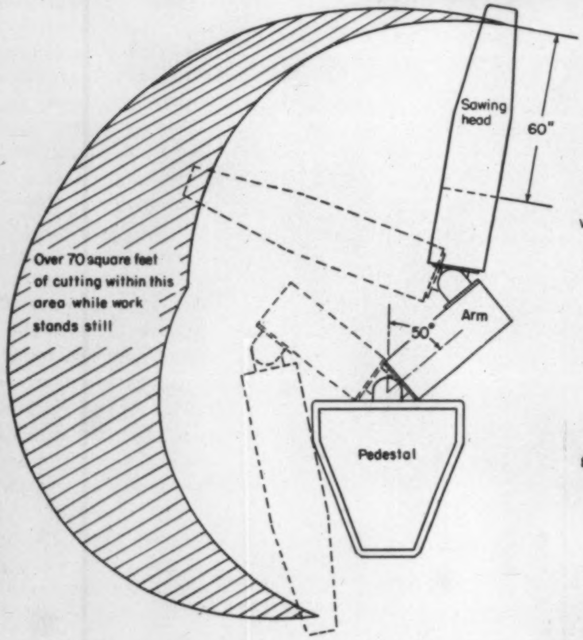
design in action

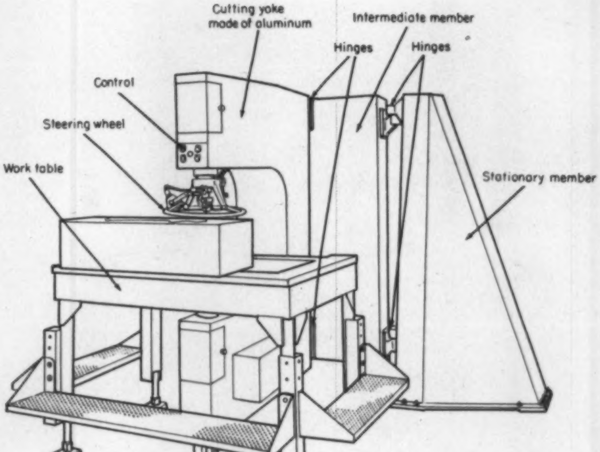
Articulated Band Saw Has

Contour sawing machine made by DoAll operates by moving tool and letting work remain stationary. This design permits the saw blade to move within an area of 70 sq ft, and it is capable of taking a straight cut 14½ ft long.



Articulated construction has three major framework members—a yoke, an intermediate member, and a stationary member. These three members are connected by hinges that employ antifriction bearings. The cutting and guiding mechanism is carried by the yoke which houses all parts for the cutting feed and power feed.


Sawing head
60"
Over 70 square feet of cutting within this area while work stands still
Arm
50°
Pedestal

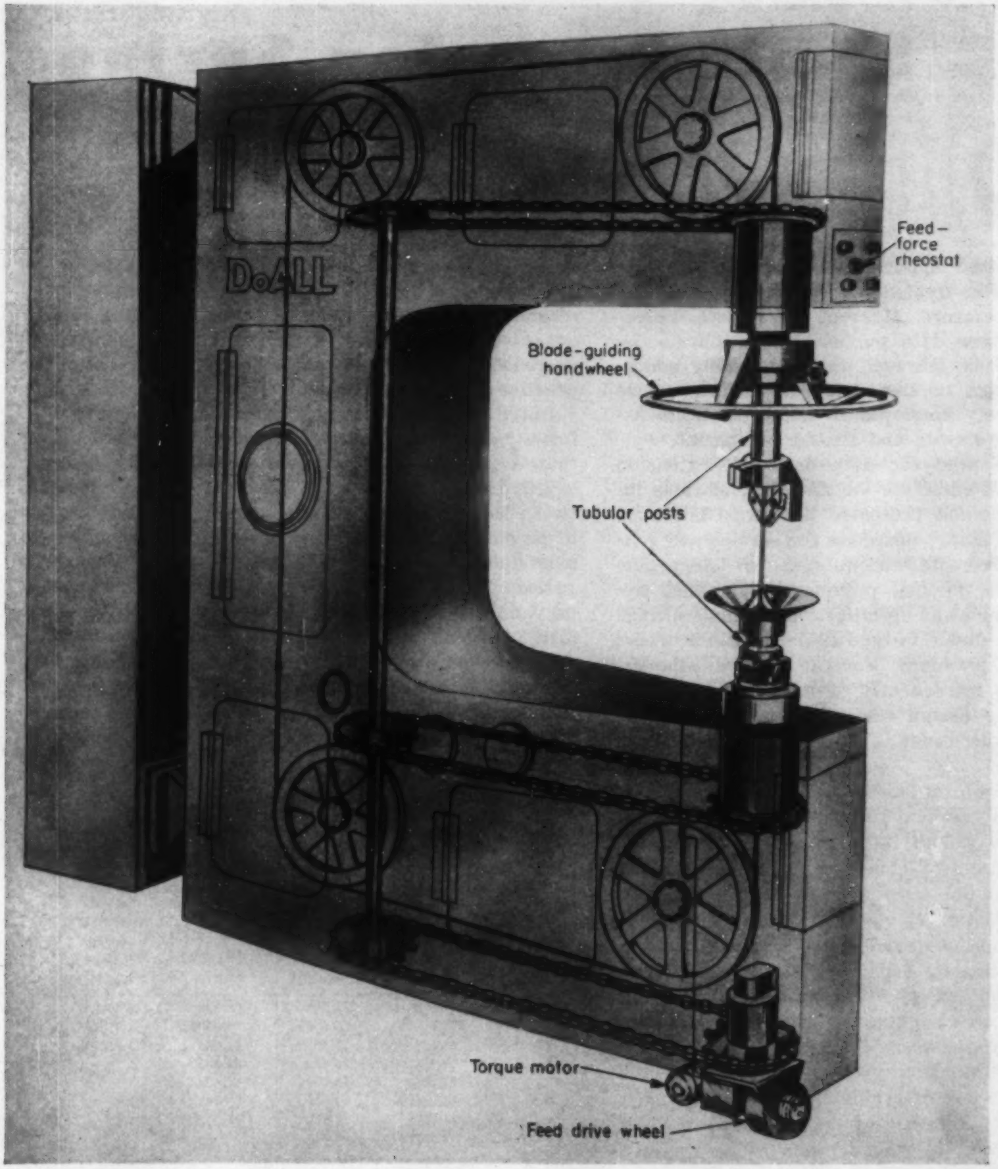

Cutting yoke made of aluminum
Intermediate member
Hinges
Hinges
Control
Steering wheel
Work table
Stationary member
Feed drive wheel

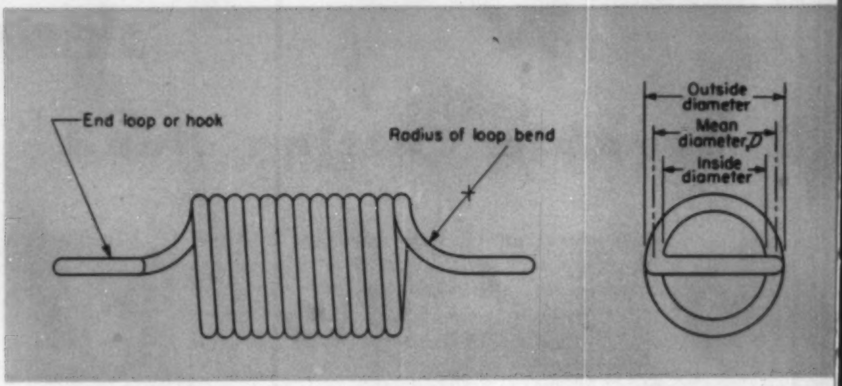
Movable Cutting Head

Four-wheel, variable-speed band-saw is housed in the yoke as shown in phantom view. Upper and lower saw-blade guides are mounted on tubular posts through which the saw blade travels. Both posts telescope to permit adjustment to varying work thicknesses.

Blade-guiding handwheel, which is connected to the top post, permits the operator to twist the saw blade 180 degrees is either direction. Turning the handwheel turns the lower feed wheel at the same time the blade is turned.

Feed drive wheel, which is a rubber-tired wheel driven by a torque motor, moves the entire yoke in the direction that the saw blade is pointed. Feed force is rheostat controlled. The wheel can be raised with an air cylinder so that the cutting head can be swung freely when desired.


DoALL
Feed-force rheostat
Blade-guiding handwheel
Tubular posts
Torque motor
Feed drive wheel



A simplified approach to design and specification of Small Extension Springs

DESIGN and application of spring elements have been treated rather extensively in recent literature. Most of the charts, nomograms and other data published to facilitate design calculations, however, are not readily adaptable to springs in the small or miniature size range commonly employed in many electrical assemblies, instruments and similar equipment.

To fill the need for data on small extension springs and to eliminate laborious calculations involved, the method presented here was developed by Western Union. Based on the service and reliability requirements encountered in telegraphic equipment, the method provides a simplified approach to design and specification of small springs for operation under fatigue load conditions where space is at a premium. For the engineer who designs springs infrequently, a brief review of extension spring design fundamentals has been included in the discussion.

Initial Tension: In an extension spring, Fig. 1, adjacent coils are held together by an initial tension which is wound into the spring during the coiling operation. When load is applied to the spring, this initial tension must be overcome before the coils start to separate.

Initial tension is wound into a spring during the coiling operation by bending the wire away from the plane it will occupy in the finished spring. This action produces a slight twist in the wire, causing each coil to spring back against the adjacent coil.

Amount of initial tension can be controlled within limits which are determined by the spring index. Wire stresses produced by initial tensions which can be conveniently wound into springs by automatic coiling equipment are given in Table 1. These data include the maximum, minimum, and recommended stress values for various spring indexes. While the limits shown in the table can be exceeded with special coiling operations, such practice should be avoided.

Initial tension is desirable in an extension spring for a number of reasons. The most important is that it permits more accurate control of the free length of the spring by eliminating clearance between adjacent coils of the spring. In addition, it permits closer tolerances on the load requirement, since the amount of initial tension can be varied. Moreover, initial tension prevents unwinding and reduces tangling of springs during handling, shipping and storing operations.

Once overcome, initial tension does not affect spring rate. It merely increases by a fixed amount the load required to extend the spring to any working length. As a general rule for close-wound extension springs, the value of initial tension

Table 1—Initial Tension Stresses and Stress Correction Factors for Extension Springs

Spring Index C	Initial Tension Stress, S_{it} (psi) Maximum	Recommended	Minimum	Correction Factor (Wahl) K
4	27,000	22,500	18,000	1.40
5	24,000	20,000	16,000	1.31
6	21,500	17,500	14,000	1.25
7	19,500	16,000	12,500	1.21
8	17,500	14,500	11,500	1.18
9	16,000	13,000	10,000	1.16
10	14,000	11,500	9,000	1.14

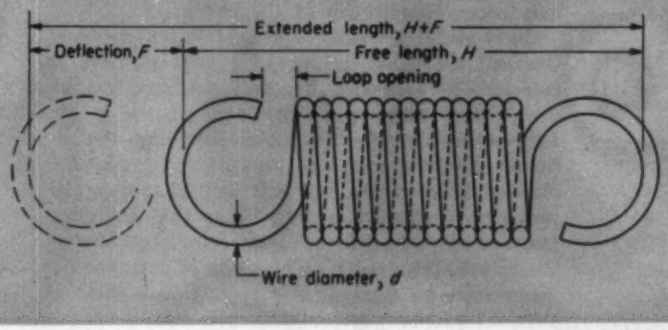


Fig. 1—Basic construction details and nomenclature for extension spring.

Basic Concepts
Wire Selection
Design Charts
Recommended Tolerances

By P. F. Recca and Fred W. Smith
Apparatus Engineers Office
The Western Union Telegraph Co.
New York

should be at least 10 per cent of the anticipated working load.

Spring Index: For extension springs, indexes (ratio of mean coil diameter to wire diameter) varying from about 4 to about 16 are possible with modern coiling equipment. Ideally, the index should be between 6 and 10. A value of 9 is usually regarded as optimum. A large index gives a "soft" spring, a small index a "hard" or "stiff" spring.

Wire curvature has a direct influence on the stresses set up during the spring coiling operation. The spring index serves as a practical measure of the amount of this curvature. Although the stresses produced by wire curvature do not affect spring rate or load-deflection characteristics, they are important in the determination of maximum safe average stress values for a specific spring design. Stress correction factors (Wahl) based on curvature effects are given for various spring indexes in Table 1.

End Connections: Several different types of end hooks or loops can be formed on extension springs to connect the applied load to the spring and to anchor the fixed end, Fig. 2. A commonly used type of end hook, which is formed by bending a full end loop, is the across-the-center or, as it is sometimes called, crossover or crossed-center end loop, Fig. 2*a*. In practice, this hook is usually formed manually with special loop-forming pliers. It is probably the least expensive end hook to produce and is quite satisfactory for springs used in light-duty applications or even in moderately severe service where stresses are conservative. However, it is not recommended for springs subject to fatigue service under cyclic load condi-

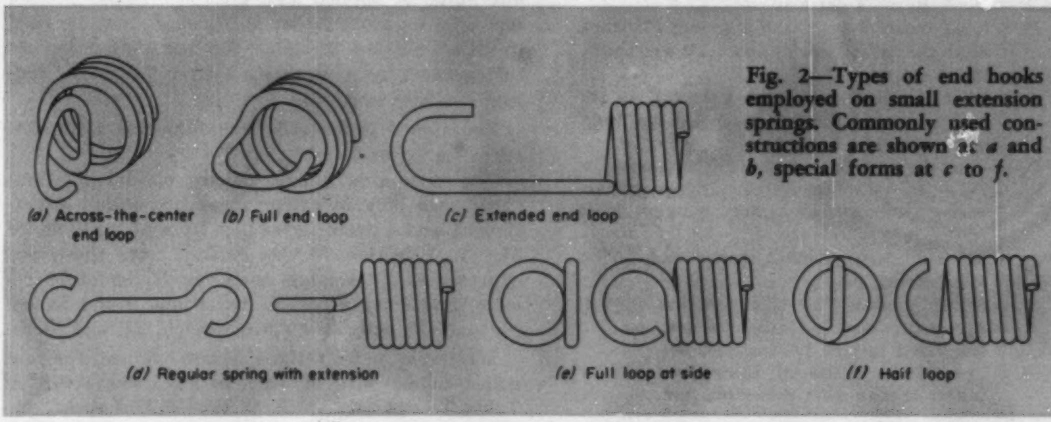

(a) Across-the-center end loop
(b) Full end loop
(c) Extended end loop
(d) Regular spring with extension
(e) Full loop at side
(f) Half loop

Fig. 2—Types of end hooks employed on small extension springs. Commonly used constructions are shown at *a* and *b*, special forms at *c* to *f*.

Table 2—Design Equations for Extension Springs*

Equation	No.
Basic Relationships	
$S = \dfrac{8PD}{\pi d^3} = \dfrac{2.55PD}{d^3}$	(1)
$f = \dfrac{8PD^3}{Gd^4} = \dfrac{0.695\,PD^3}{d^4(10^6)}$	(2)
Equations Derived From Basic Relationships	
$f = \dfrac{\pi\,S_f\,D^2}{Gd} = \dfrac{0.273\,S_f\,D^2}{d(10^6)}$	(3)
$d^2 = \dfrac{8PC}{\pi S}$	(4)
$P_1 = \dfrac{FGd^4}{8D^3N} = \dfrac{1.437\,Fd^4(10^6)}{D^3N}$	(5)
$P_m = \dfrac{\pi\,S_m\,d^3}{8D} = \dfrac{0.393\,S_m\,d^3}{D}$	(6)
Special Extension Spring Equations	
$S_f = S_t - S_{it}$	(7)
$L = H + Nf$	(8)
$H = (N + 1)d + 2(D - d)$	(9)
$\mathrm{N} = \dfrac{L - 2D + d}{d + f}$	(10)

*Based on music wire, $G = 11.5 \times 10^6$ psi

Nomenclature

$C = D/d$ = Spring index
D = Mean diameter (outside diameter minus wire diameter), in.
d = Wire diameter, in.
$F = Nf$ = Spring deflection, in.
F_2 = Spring deflection at fatigue-limit load, in.
F_{min} = Minimum recommended spring deflection, in.
f = Deflection per coil or turn, in.
G = Shear modulus of spring wire, psi
H = Free length inside end loops, in.
K = Stress correction factor (Wahl)
L = Extended length of spring inside the end loops, in.
N = Total number of turns
$P = P_1 + P_{it}$ = Axial load, lb
P_1 = Load required to extend a spring F inches after the initial tension has been overcome, lb
P_2 = Load required to extend a spring to its fatigue limit after initial tension has been overcome, lb
P_{it} = Load required to overcome initial tension, lb
$P_m = P_2 + P_{it}$ = Maximum permissible load on spring without exceeding fatigue limit stress, lb
P_{min} = Minimum recommended spring load, lb
S = Wire stress, psi
S_f = Stress produced by spring deflection, psi
S_{it} = Stress produced by initial tension, psi
S_m = Corrected fatigue limit stress, psi
S_t = Total fibre stress in shear produced by initial tension plus deflection, psi

tions because of the stress concentration present in the sharp bend produced by forming the end loop across the center of the spring.

Since most extension spring failures occur at the end hooks, it is essential that stresses in this area be kept low. The full end loop, Fig. 2*b*, avoids the stress concentrations set up in the across-the-center design while retaining the inherent advantage of this type of end hook. Radius of bend of the full end loop should be approximately one-half spring ID so that the curvature of the loop will not be greater than that of the other spring coils. This type of end hook is inexpensive to form and is readily assembled to a round anchor post or similar mounting means. Loop opening should be approximately one-third to one-half mean coil diameter.

Extension springs are sometimes subject to oscillation when the rate at which the load is applied approaches the natural frequency of the spring. Such oscillations act to increase the effective deflection of the spring and, thus, wire stress. In small springs, it is often possible to eliminate these oscillations by insertion of a felt wick or oiler in the spring core to provide damping action. This operation is a fairly simple one when full end loops are used on the spring, but not when across-the-center hooks are employed.

Several special end hooks are illustrated in Figs. 2*c, d, e,* and *f*. Such constructions are occasionally necessary but should be avoided if possible since they usually limit range of possible spring application and/or increase cost. When a spring with an extended end loop is required, preferred practice is the standard spring and extension arm assembly, Fig. 2*d*, rather than the one-piece design at Fig. 2*c*.

Design Calculations: Basic equations for design of extension springs are given in Table 2. Symbols are defined in Nomenclature and Fig. 1. Equations 1 and 2 represent fundamental spring relationships. Equation 3 is derived by solving for P in each of these expressions, equating the results, and simplifying. Equation 4 is derived from Equation 1 by substituting C for D/d. Equation 5 is derived from Equation 2 by substituting F/N for f and P_1 for P. Note that Equation 2 applies for any value of applied load after the initial tension has been overcome; that is, P_1 or P_2 may be used in this equation to solve for the deflection per turn caused by a given load after the initial tension has been overcome.

Equation 6 is derived from Equation 1 by substituting S_m for S and P_m for P.

The remaining equations are special relationships used only in extension spring design. Equations 8 and 9 were developed from an analysis of Fig. 1. Equation 10 was derived from these two expressions by solving each for H, equating results, and solving for N. Equations 9 and 10 apply only to extension springs with full end loops.

Maximum safe fatigue stress values for uncoiled music wire of various sizes are given in Table 3. For any value of load P and spring index *C*, the wire size to give this maximum safe stress when coiled can be calculated by dividing this stress by the Wahl correction factor and then substituting these values of *P*, *S*, and *C* in Equation 4. Recommended minimum wire sizes given in Table 4 for different values of load and spring index were determined in this manner.

Maximum wire size for a given load and spring index can also be determined, but the method is necessarily more or less arbitrary. In Table 4, consideration was given to the problem of maintaining close load tolerances on small extension springs. As a practical approach, a load tolerance of ±10 per cent is generally acceptable to spring manufacturers. However, this tolerance is difficult to maintain at low values of total stress, where the initial tension load is a relatively large percentage of the total load. Maximum wire sizes recommended in Table 4 are such that required load *P* will produce an elongation in the spring of one-third total deflection from free length to fatigue-limit length. Determination of these maximum wire diameters is covered in the following discussion.

For a given load and spring index, wire stress produced by the load is a minimum when wire diameter is a maximum. If this minimum stress, corresponding to a given load, is to occur at the point of ⅓ total deflection, then

$$S_{min} = \frac{1}{3}\left(\frac{S}{K} - S_{it}\right) + S_{it}$$

where S_{min} is the minimum stress and S is the fatigue-limit stress of the wire.

Table 3—Fatigue-Limit Stresses for Music Wire

Wire Diameter (in.)	Fatigue-Limit Stress (psi)
0.005 to 0.030	85,000
0.031 to 0.050	80,000
0.051 to 0.080	75,000
0.081 to 0.125	70,000

Maximum wire diameter can now be calculated from Equation 4 by substituting the values of S_{min} and assumed load for S and P.

Although either maximum or minimum wire size given in Table 4 may be used in designing a spring for a given load and index, recommended practice is to choose a wire diameter which falls about midway between the two. This will give a well proportioned spring in which the maximum stress developed by the working load will be well below the fatigue limit of the wire.

The wire sizes shown in Table 4 are calculated values. To avoid costly special wire-drawing operations, however, it may be necessary to alter these sizes to conform to available standard diameters.

Design Procedure: In the design of extension springs, the required load at a given extended length is usually known. This extended length is, of course, fixed by the design of the assembly in which the spring is to be used, but frequently can be changed within limits by relocating spring posts or other mounting brackets. Required load at this length can be determined from design experience on similar equipment or through tests on laboratory models.

When the required load at any extended length has been established, wire diameter and mean coil diameter can be selected from Table 4 by

Table 4—Recommended Wire Sizes for Extension Springs

Required Load, P	Wire Diameter, d									
	$C = 6$		$C = 7$		$C = 8$		$C = 9$		$C = 10$	
	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
1 oz	...	...	...	...	0.006	...	0.006	...	0.007	0.006
2	0.007	0.006	0.008	0.006	0.008	0.006	0.009	0.007	0.010	0.007
3	.009	.007	.010	.007	.010	.008	.011	.008	.012	.009
4	.010	.008	.011	.008	.012	.009	.013	.009	.014	.010
5	.012	.009	.013	.009	.014	.010	.014	.010	.015	.011
6	.013	.010	.014	.010	.015	.011	.016	.011	.017	.012
7	.014	.010	.015	.011	.016	.012	.017	.012	.018	.013
8	.015	.011	.016	.012	.017	.012	.018	.013	.020	.013
9	.016	.012	.017	.012	.018	.013	.020	.014	.021	.014
10	.016	.012	.018	.013	.019	.014	.021	.014	.022	.015
11	.017	.013	.019	.014	.020	.014	.022	.015	.023	.016
12 oz	.018	.013	.020	.014	.021	.015	.023	.016	.024	.016
1 lb	.021	.015	.023	.016	.024	.017	.026	.018	.028	.019
1.25	.023	.017	.025	.018	.027	.019	.029	.020	.032	.020
1.5	.026	.019	.028	.020	.031	.021	.033	.022	.035	.023
1.75	.028	.020	.031	.022	.033	.023	.035	.024	.038	.025
2.0	.030	.022	.033	.023	.035	.024	.038	.025	.040	.027
2.5	.034	.024	.037	.026	.039	.027	.042	.028	.045	.030
3.0	.037	.026	.040	.028	.043	.030	.046	.032	.049	.033
3.5	.040	.028	.043	.030	.047	.033	.050	.035	.055	.036
4.0	.043	.030	.046	.033	.050	.035	.055	.037	.058	.038
4.5	.045	.033	.049	.035	.054	.037	.058	.039	.062	.041
5.0	.048	.035	.053	.037	.057	.039	.061	.041	.065	.043
6.0	.053	.038	.058	.041	.063	.043	.067	.045	.071	.047
8.0	.062	.044	.067	.047	.072	.049	.078	.054	.085	.056
10	.069	.049	.075	.054	.083	.057	.089	.060	.095	.063
12 lb	.076	.056	.084	.059	.091	.063	.097	.066	.104	.069

All dimensions in in. unless otherwise noted.

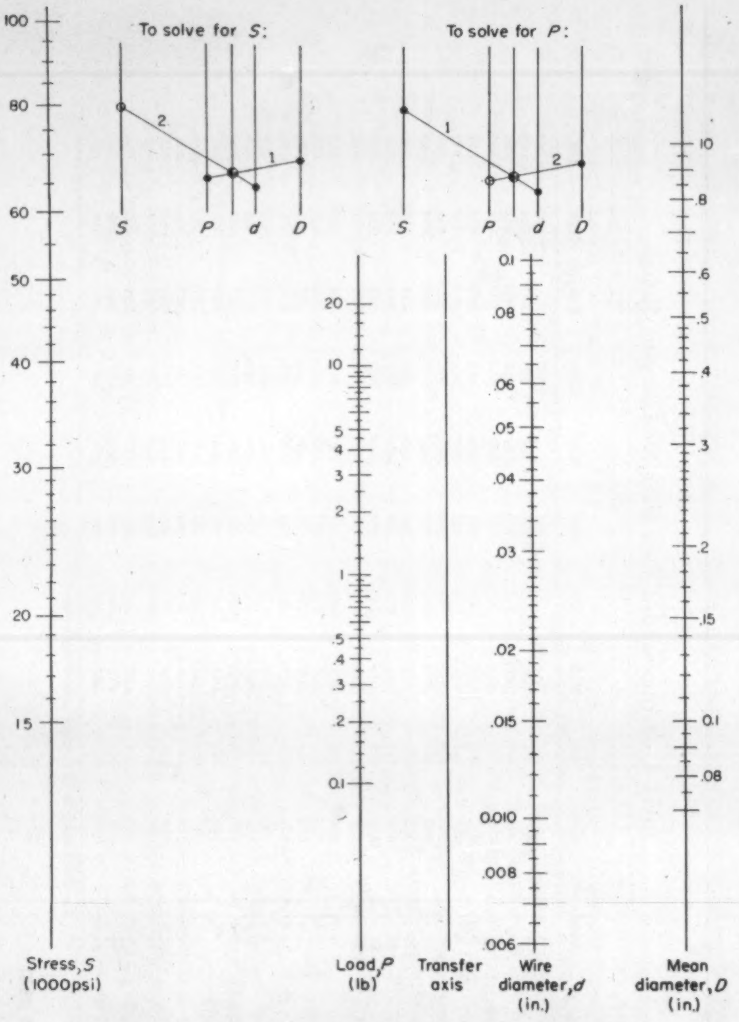


Fig. 3—Design nomogram for determination of loads and stresses in small extension springs.

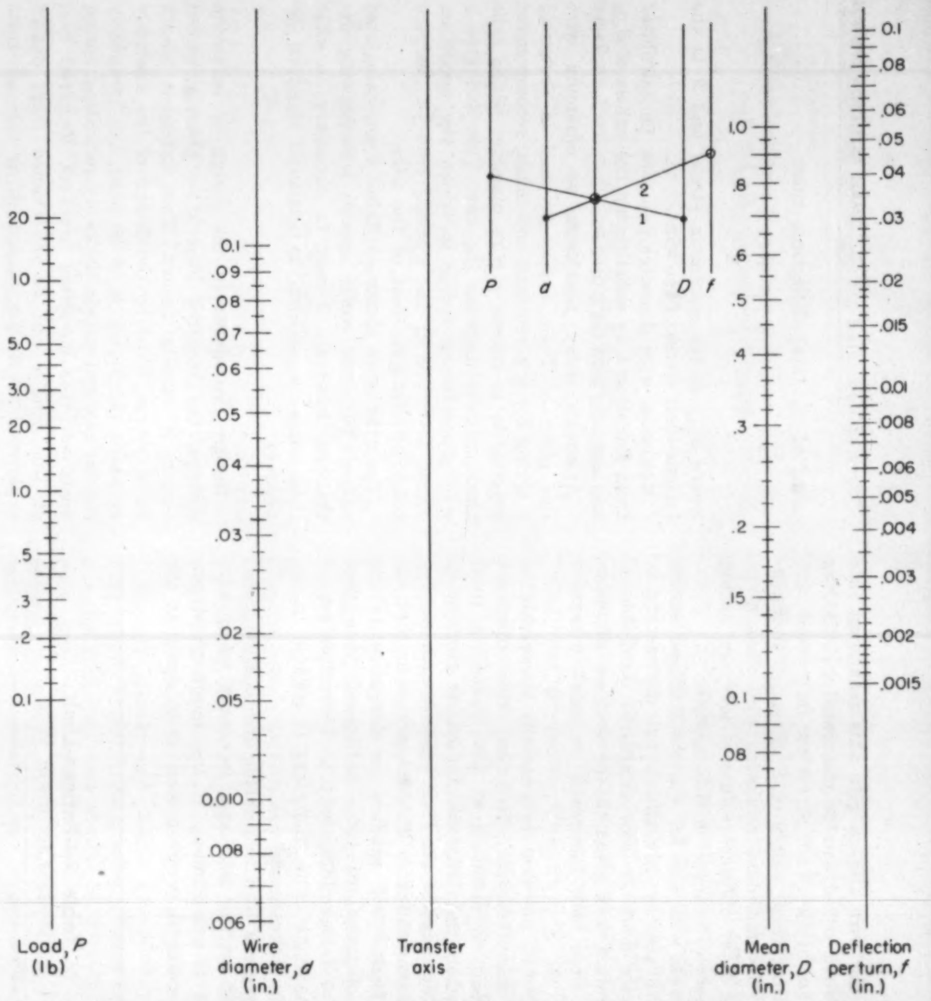


Fig. 4—Design nomogram for determination of deflection per turn in small extension springs.

assuming a spring index. If outside diameter of the spring is not limited, an index of 8 or 9 should be assumed. However, if maximum allowable diameter is limited, trial and error determination of spring index and wire size from the table may be necessary.

When wire size and spring index have been determined, total wire stress produced by initial tension plus deflection of the spring can be determined from Equation 1. Initial tension stress can then be selected from Table 2. Stress produced in the wire by deflection of the spring is given by Equation 7.

Deflection per turn of the spring can be found from Equation 3, using the stress value given by Equation 7. Final step in the design procedure is to determine the number of turns and the free length of the spring. Number of turns N can be found from Equation 10. Then, for a spring with full end loops, working length L is given by Equation 8 and free length H by Equation 9.

For small extension springs, application of this procedure in design calculations is greatly simplified by the nomograms presented in Figs. 3 and 4. Based on published charts for larger springs, these nomograms have been developed to meet the wire diameter and load requirements of small steel springs of the type employed in telegraph and similar equipment. Accuracy of the nomogram solution is sufficient for most small spring design problems.

Each of the nomograms has four scales and a transfer axis. The nomogram in Fig. 3 is used for calculations involving load, stress, wire diameter and mean diameter; that in Fig. 4 for calculations involving load, wire diameter, mean diameter and deflection per turn.

EXAMPLE SOLUTION: Design a spring to develop a 4-oz load at an extended length of 1.375 in. Maximum permissible OD of the spring is 0.125-in.

Table 5—Recommended Free Length Tolerances for Extension Springs

Free Length (in.)	Tolerance (in.)
0 to ½	±0.015
½ to ¾	±0.020
¾ to 1	±0.031
1 and over	±(0.047 + 0.015x)*

*x = Number of inches in excess of 1 in. length.

Table 6—Recommended Outside Diameter Tolerances for Extension Springs

Outside Diameter (in.)	Tolerance (in.)
0 to ⅛	±0.003
over ⅛ to 3/16	±0.004
over 3/16 to ¼	±0.006
over ¼ to ⅜	±0.008
over ⅜ to ½	±0.010
over ½ to ¾	±0.012
over ¾ to 1	±0.015

A spring index of $C = 9$ will be assumed first. From Table 4, for required load $P = 4$ oz and $C = 9$, wire diameter range is 0.009 to 0.013-in. As a first trial, a standard wire size, $d = 0.012$-in., will be used. Mean diameter $D = 9(0.012) = 0.108$-in. and, thus, OD $= 0.108 + 0.012 = 0.120$-in. which is within specified limits.

From Table 1 for $C = 9$, recommended initial tension stress $S_{it} = 13{,}000$ psi and Wahl correction factor $K = 1.16$. From Table 3, fatigue limit stress for 0.012-in. diameter music wire is 85,000 psi. Correcting this value for effect of curvature gives $S_m = 85{,}000/1.16 = 73{,}300$ psi.

In the nomogram of Fig. 3, connect $P = 4$ oz $= 0.25$-lb to $D = 0.108$-in. with a straight line. Through the intersection of this line with the transfer axis, draw a line from $d = 0.012$-in. to the S scale, giving total stress $S_t = 39{,}900$ psi. From Equation 7 then, stress due to deflection alone is $S_f = 39{,}900\text{-}13{,}000 = 26{,}900$ psi.

In this same nomogram, connect $S_f = 26{,}900$ psi to $d = 0.012$-in. Through the transfer axis intersection, draw a line from $D = 0.108$-in. to the P scale. Find $P_1 = 0.17$-lb which is the load at deflection stress S_f. Similarly, for $S_m = 73{,}300$ psi, following this same procedure gives maximum permissible load $P_m = 0.46$-lb.

Load corresponding to initial tension stress is $P_{it} = 0.25 - 0.17 = 0.08$-lb. Therefore, the load required to extend the spring to its maximum safe length is: $P_2 = 0.46 - 0.08 = 0.38$-lb. $= 6.08$ oz.

To find deflection per turn, the nomograph in Fig. 4 is used. Connect $P_1 = 0.17$-lb to $D = 0.108$-in. Through the transfer axis intersection, draw a line from $d = 0.012$-in. to the f scale, giving $f = 0.0072$-in. per turn. In the same manner, for $P_2 = 0.38$-lb, deflection per turn at the fatigue limit is found to be $f_2 = 0.0162$-in.

From Equation 10, total number of turns $N = 61$. This particular solution can be used directly, but such convenient results are not always the case. For a spring with end loops at right angles, the number of turns should be selected to nearest quarter or three-quarters of a turn. For a spring with end loops in the same plane, the number of turns should be chosen to the nearest half or full number of turns.

From Equation 9, free length $H = 0.936$-in. Total deflection of the spring at the working load is $F = 1.375 - 0.936 = 0.439$-in. Total elongation of the spring at the fatigue limit is $F_2 = 0.0162(61) = 0.988$-in.

Load-Extended Length Chart: As a check on design calculations, a load-extended length chart, Fig. 5, for the spring should be constructed. This chart is also helpful in evaluating the spring design for possible use in future applications.

In the chart construction, load (ordinate) is plotted against extended length (abscissa). Three points are used to determine the plot: (1) load P_{it} at zero deflection; (2) load P and deflection F at working length; and (3) load P_m and deflection F_2 at maximum safe length (fatigue limit). Extended length at each point is found by adding free height H to the deflection value.

Consider the previous example. The load-extended length chart for this spring design is plotted in Fig. 5. Reference data for the plot are: (1) $P_{it} = 0.08$-lb $= 1.28$ oz, $H = 0.936$-in.; (2) $P =$

4 oz, $F + H = 1.375$ in.; and (3) $P_m = 0.46$-lb = 7.36 oz, $F_2 + H = 0.988 + 0.936 = 1.924$ in.

These three points should fall on a straight line when plotted, as shown in Fig. 5. Failure of the points to line up indicates error in the calculations.

Minimum working length at which the spring can be used without exceeding the recommended ±10 per cent load tolerance should be shown on the chart. Deflection at this length, based on the considerations discussed previously, should be one-third of the total deflection from free length to fatigue limit, or six times the free length tolerance given in Table 5, whichever is greater.

In the design example given here, one-third of the total deflection is $0.988/3 = 0.329$-in., and six times the free length tolerance is $6(0.031) = 0.186$-in. Thus, a line should be drawn on the chart at the 0.329-in. deflection point (1.265-in. extended length) to indicate the minimum recommended working length of the spring, Fig. 5. Although the spring can be used at smaller deflections, the load tolerance could not be reliably held to the ±10 per cent requirement below this point. The minimum recommended load, P_{min}, at this point is:

$$P_{min} = \frac{P_2 F_{min}}{F_2} + P_{it} = \frac{6.08(0.329)}{0.988} + 1.28 = 3.30 \text{ oz}$$

Table 7—Typical Design Specification for Small Extension Spring

Material	Steel music spring wire (ASTM—A-228)	
Wire diameter		0.012-in.
Mean coil diameter		0.108-in.
Outside diameter		0.120 ± 0.003-in.
Number of turns		61 ± 2
Free length		0.936 ± 0.031-in.
Radius of loop bend		0.047 ± 0.010-in.
Loop opening		0.047 ± 0.010-in.
Type of end loop		Parallel
Direction of winding		Either
Test Data	Length (in.)	Load (oz)
	1.265	3.30 ± 1/3
	1.924	7.36 ± ¾

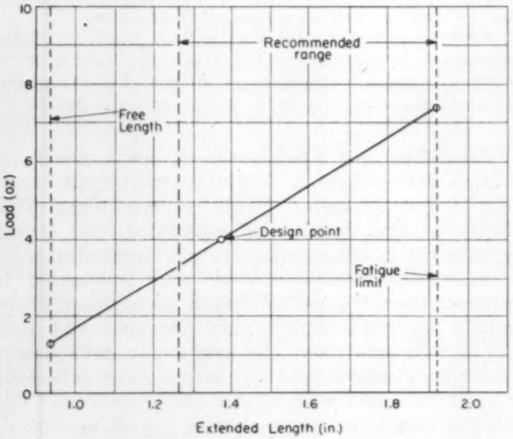


Fig. 5 — Construction of load-extended length chart for checking spring design calculations.

Tolerances: Final step in the design of a spring is to select tolerances for outside diameter, free length, number of turns and required load. These specified tolerances should be readily obtainable on automatic spring winding machines. Tables 5 and 6 give tolerances on free length and outside diameter that are acceptable to most spring manufacturers. Closer tolerances than those listed should be avoided wherever possible.

The tolerance on number of turns should be 5 per cent of the number of turns to the nearest half turn with a maximum of two turns. Tolerances on wire diameters are covered by ASTM standards (No. A-228) and need not be specified. Tolerances on loads should be 10 per cent. For radius of loop bend and for loop opening, tolerances should be at least 15 per cent of the nominal dimension or 0.010-in., whichever is greater.

A typical specification for a small extension spring, based on the previous design example, is given in Table 7.

ACKNOWLEDGEMENT

The authors acknowledge with appreciation the co-operation of American Steel and Wire Div. of U. S. Steel Corp. in granting permission to reproduce the modified nomograms shown in Figs. 3 and 4.

BIBLIOGRAPHY

1. A. M. Wahl—*Mechanical Springs*, Penton Publishing Co., Cleveland, 1949.
2. American Society of Tool Engineers—*Practical Design of Mechanical Elements*, McGraw-Hill Book Co., New York.
3. *Manual of Spring Engineering*, American Steel and Wire Div., United States Steel Corp., Cleveland.

Tips and Techniques

Estimating Bar Weight

The approximate weight of steel bar stock can be readily estimated by using one of two simple formulas.

For squares or rectangles, multiply width by the height, add a zero, and then divide by 3. This gives the weight in pounds per ft. Example: Bar size 6 by 2 in: $6 \times 2 = 12$; add a zero to produce 120; $120/3 = 40$ lb per ft.

For rounds, multiply the diameter by 4, square the result, and divide by 6. Example: Bar size 2 in. diam: $2 \times 4 = 8$; $8^2 = 64$; $64/6 = 10\ 2/3$ lb per ft.—WILLIAM R. LOCKE, *Cincinnati.*

Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables or photos to: Tips and Techniques Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

The Personal Side of Engineering

By Edwin C. Nevis
Personnel Research and Development Corp., Cleveland

What Are Engineers Made Of?

Part 1

PEOPLE like to invoke stereotypes in discussing persons belonging to a particular occupational group. Salesmen are frequently described as "extroverted," "persuasive," "glib," and "fast-moving." Engineers are often called "reflective," "stubborn," "unemotional," and "meticulous."

Such typing—whether true or not—can serve a useful function. It helps outsiders, and group members too, to make judgments about and to react to members of the occupational group in a consistent manner. Stereotyping also serves—probably too much so—as a frame of reference for young people faced with a choice of careers. Because of the tenacity with which people hold to a stereotype, any misconception behind such a prejudiced view is difficult to change.

Probably no occupational group has become heir to as tightly rigid and universal a stereotype as that of the engineer. Research studies and experience of trained observers indicate wide variation in personality characteristics of engineers, as well as some common characteristics. But the use of flat generalizations continues. Why? Probably because the engineering profession comes closer to being a well-defined occupational group than any other in industry today.

Despite the difficulty of defining a group's characteristics, some factors seem to appear frequently enough in the make-up of engineers to give the engineering group a distinctive "color." However, any mental picture of an engineer should be based upon factual prototypes rather than stereotypes. In the final analysis, it is necessary to know each engineer as an individual, and the ways in which he differs from and agrees with the general pattern. As a starting point the common elements need enumeration.

To begin with, we may consider the engineer's approach to work and the meaning of work to him. Most engineers possess superior problem-solving ability. If anything can be stated as a generalization about engineers' work, it is that it is related to the solution of problems of one sort or another. An engineer may be concerned with a fairly mundane type of drafting activity; he may be concerned with the idea stages in the creation of a new product. But whatever his work, his efforts are by and large directed toward the application of knowledge and basic principles to the solution of specific problems.

This requirement helps explain an outstanding characteristic demonstrated by engineers: their perfectionism and their insistence upon doing a thorough job. Having a strong aversion to ambiguity and to work which is not tightly organized and well-formulated, engineers go stubbornly after the best solution to a problem.

In addition to emphasizing logic in the solution of problems, engineers as individuals tend to stick firmly to their guns after reaching a conclusion. More than most other occupational groups, engineers are disturbed by being in the dark about a problem and proceeding without clear definition or ground rules. And, once having learned how to replace vagueness with clarity, they find it hard to believe that there are problems in which factually correct solutions are hard to come by. For this reason, engineers as a group often find it difficult to make the compromises needed to solve human relations problems.

Along with a tendency toward perfectionism, engineers show a highly practical and action-oriented outlook. Those who view the engineer as a scientist are apt to be a little confused by the fact that engineers have their feet more firmly on the ground than most scientists. Engineers are usually highly skilled action-oriented individuals for whom immediate application in concrete situations is important. Evidence shows that few engineers are able to work for long periods of time without seeing tangible results follow from their efforts.

Of course, this generalization can be misleading. Research engineers, for example, are probably most content with a lack of immediate results—at least they should be to feel comfortable in their job. Application engineers and engineers serving in production capacities have jobs requiring aggressiveness in obtaining more immediate results. On the whole, though, engineers are concerned with processes and methods closely related to the production of concrete results. Success in these activities requires a more action-minded person than the term "reflective" would warrant.

In conjunction with perfectionism and practicality in solving problems, engineers are concerned with real accomplishment rather than with the material rewards and status that can follow achievement. Engineers tend to become so engrossed and challenged by the task that lies before them that the solution of the problem becomes rewarding in itself. So much so, in fact, that other rewards and recognition that might follow are of secondary importance.

In finding so much satisfaction in the work itself, engineers—at least in the past—have shown little concern for such things as working conditions, self-development, and ways of advancing in status. With recent emphasis upon expanding the social outlook of the engineer this situation is changing somewhat. Engineers in relation to their training and contribution are beginning to feel that they are perhaps not so well off, financially and status-wise, as other recognized groups in industry. And it is probably lack of recognition of their contribution, more than concern for money *per se*, that disturbs engineers.

One misconception concerning engineers is that they are highly detail-minded or overly meticulous in their work habits, as well as in their personal lives. While some engineers are most effective and feel most comfortable when they are doing highly routinized, detail work, there is wide variation among engineers. Though most engineers tend to think in logical, orderly ways, many engineers are found to be quite poor in handling details—some to the point of real sloppiness.

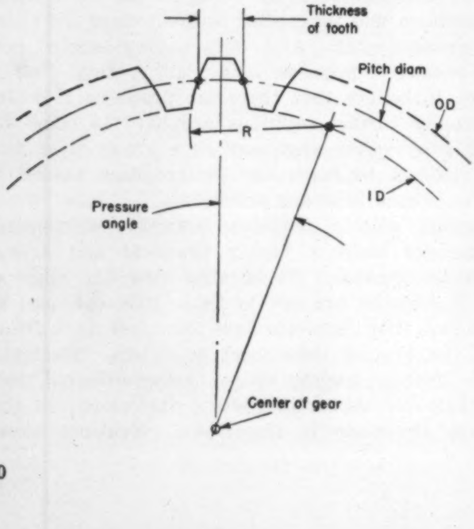
To summarize, evidence concerning the engineer's approach to work and the satisfactions he derives from it shows that isolated qualities are not the exclusive property of a single occupational group. At the same time, research studies and technical experience do indicate engineers as a group to be perfectionistic, systematic, logical in emphasis, and highly absorbed in the task of obtaining tangible daily accomplishments rather than the rewards that may follow.

This discussion of "What Are Engineers Made Of?" will be continued in the next column.

Tips and Techniques

Drawing Gear Teeth

When drawing gears, application of certain simplified practices can result in real time savings. First draw only one tooth and complete the circle with dashed lines. A simple procedure for construction of the single tooth consists of first drawing the OD, ID and pitch-diameter circles. Then tooth thickness is lightly indicated on the pitch circle. Next intersect the ID circle with a line drawn from the gear center at an angle with the tooth centerline equal to the pressure angle. Use this intersection as the center for drawing the tooth contour with a compass.—George D. Pheil, *Racine, Wis.*



Experimental Parts

Often in experimental work a part must be made from sheet metal to determine its relationship with other parts. Blueing layouts can be made and are, of course, perfectly satisfactory. However, there is an easier method if some of the accuracy of the blueing layout can be sacrificed. First make a full scale drawing of the part. Then tape the drawing and a piece of carbon paper to the sheet metal and trace the outline of the part onto the sheet metal using either a hard pencil or a stylus.—Benjamin Myers, *Sylvania Electric Products Inc., Kew Gardens L. I., N. Y.*

Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables or photos to: Tips and Techniques Editor, Machine Design, Penton Bldg., Cleveland 13, O.

Co-ordinate Constants for

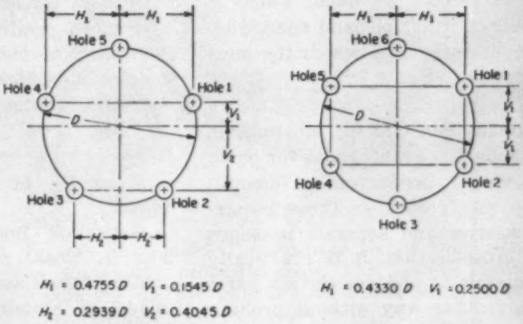
Bolt-Hole Circles

By Donald E. Sweet
Marblehead, Mass.

HORIZONTAL and vertical co-ordinates of equally spaced bolt holes are easily computed but the work is tedious and repetitious. The accompanying table presents constants from which co-ordinates can be calculated with minimum effort and maximum accuracy.

The tabulated constants are, in effect, bolt-hole co-ordinates for a 1-in. diameter bolt circle. Actual dimensions for a circle of any diameter are obtained simply by multiplying the constants by the circle diameter.

For compactness the minimum required number of co-ordinates are listed in the table. In the notation system, the last numbered hole is located at the top on the vertical axis, as shown by the sketched examples. Co-ordinates for holes not listed are, of course, identical to those shown because of symmetry.



$H_1 = 0.4755D$ $V_1 = 0.1545D$

$H_2 = 0.2939D$ $V_2 = 0.4045D$

Five Holes

$H_1 = 0.4330D$ $V_1 = 0.2500D$

Six Holes

Bolt-hole circle examples. Only two sets of constants are needed to define locations for the five-hole case, and only one set for the six-hole example.

Constants for Bolt-Hole Circle Co-ordinates

Hole	Hor.	Ver.	Hor.	Ver.	Hor.	Ver.	Hor.	Ver.	Hor.	Ver.	Hor.	Ver.	Hor.	Ver.	Hor.	Ver.	Hor.	Ver.	Hole
	5 Holes		6		7		8		9		10		11		12		13		
1	0.4755	0.1545	0.4330	0.2500	0.3910	0.3116	0.3535	0.3535	0.3214	0.3830	0.2939	0.4045	0.2703	0.4206	0.2500	0.4330	0.2324	0.4427	1
2	.2939	.4045	....	....	.4875	.1112	....	....	.4924	.0868	.4755	.1545	.4548	.2077	.4330	.2500	.4115	.2840	2
3	....	....	....	....	.2168	.4505	....	....	.4330	.2500	....	....	.4949	.0712	....	....	.4963	.0603	3
4	....	....	....	....	....	....	....	....	.1710	.4698	....	....	.3778	.3274	....	....	.4675	.1773	4
5	....	....	....	....	....	....	....	....	....	....	....	....	.1408	.4797	....	....	.3315	.3742	5
6	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	.1196	.4855	6
	14 Holes		15		16		17		18		19		20		21		22		
1	0.2168	0.4505	0.2034	0.4568	0.1913	0.4619	0.1806	0.4662	0.1710	0.4698	0.1623	0.4729	0.1545	0.4755	0.1473	0.4777	0.1409	0.4797	1
2	.3910	.3116	.3716	.3346	.3535	.3535	.3368	.3695	.3214	.3830	.3070	.3945	.2939	.4045	.2816	.4131	.2703	.4206	2
3	.4875	.1112	.4755	.1545	.4619	.1913	.4475	.2229	.4330	.2500	.4185	.2735	.4045	.2939	.3909	.3117	.3779	.3274	3
4	....	....	.4973	.0523	....	....	.4978	.0461	.4924	.0868	.4847	.1227	.4755	.1545	.4655	.1826	.4548	.2077	4
5	....	....	.4330	.2500	....	....	.4809	.1368	....	....	.4983	.0412	....	....	.4986	.0373	.4949	.0712	5
6	....	....	.2939	.4045	....	....	.3990	.3013	....	....	.4529	.2007	....	....	.4875	.1112	....	....	6
7	....	....	.1039	.4891	....	....	.2632	.4251	....	....	.3679	.3385	....	....	.4330	.2500	....	....	7
8	....	....	....	....	....	....	.0918	.4914	....	....	.2380	.4397	....	....	.3400	.3665	....	....	8
9	....	....	....	....	....	....	....	....	....	....	.0824	.4931	....	....	.2169	.4505	....	....	9
10	....	....	....	....	....	....	....	....	....	....	....	....	....	....	.0745	.4944	....	....	10
	23 Holes		24		25		26		27		28		29		30		32		
1	0.1349	0.4814	0.1294	0.4830	0.1243	0.4843	0.1196	0.4855	0.1153	0.4865	0.1112	0.4875	0.1074	0.4883	0.1039	0.4891	0.0975	0.4904	1
2	.2597	.4272	.2500	.4330	.2408	.4381	.2324	.4427	.2244	.4468	.2168	.4505	.2090	.4543	.2034	.4568	.1913	.4619	2
3	.3654	.3413	.3535	.3535	.3422	.3645	.3315	.3742	.3214	.3830	.3116	.3910	.3025	.3931	.2939	.4045	.2778	.4157	3
4	.4439	.2300	.4330	.2500	.4221	.2679	.4115	.2840	.4010	.2986	.3910	.3116	.3811	.3237	.3716	.3346	.3535	.3535	4
5	.4895	.1017	.4830	.1294	.4755	.1545	.4675	.1773	.4541	.1975	.4505	.2168	.4417	.2342	.4330	.2500	.4157	.2778	5
6	.4988	.0341	....	....	.4990	.0314	.4963	.0603	.4924	.0868	.4875	.1112	.4817	.1338	.4755	.1545	.4619	.1913	6
7	.4711	.1675	....	....	.4911	.0937	....	....	.4991	.0291	....	....	.4992	.0271	.4978	.0523	.4904	.0975	7
8	.4085	.2883	....	....	.4524	.2129	....	....	.4790	.1434	....	....	.4934	.0808	....	....	....	....	8
9	.3087	.3933	....	....	.3852	.3187	....	....	.4330	.2500	....	....	.4645	.1850	....	....	....	....	9
10	.1992	.4086	....	....	.2939	.4045	....	....	.3637	.3431	....	....	.4138	.2805	....	....	....	....	10
11	.0681	.4953	....	....	.1840	.4649	....	....	.2747	.4177	....	....	.3439	.3629	....	....	....	....	11
12	....	....	....	....	.0626	.4960	....	....	.1710	.4698	....	....	.2578	.4284	....	....	....	....	12
13	....	....	....	....	....	....	....	....	.0580	.4966	....	....	.1597	.4738	....	....	....	....	13
14	....	....	....	....	....	....	....	....	....	....	....	....	.0541	.4970	....	....	....	....	14

Bolt-Hole Circles

DESIGN ABSTRACTS

New applications for Shell Castings

By H. G. Sieggreen
Chief Engineer
Central Foundry Div.
General Motors Corp.
Saginaw, Mich.

THE process of shell molding derives its name from the physical nature of the mold, which is a shell or wafer of sand bonded by phenolic resin, into which the metal is poured, Fig. 1.

Advantages: Shell molding is particularly advantageous for quick and simple production of complicated molds such as those requiring narrow and accurate passages and cross-section. It is practically impossible to produce certain parts in any other way without prohibitive costs. This is especially true of ferrous metals.

Another major advantage of the shell-mold process is the reduction in the number of subsequent machining operations required to complete a part. The dimensional tolerances and surface finish obtainable in making parts by the shell-mold process eliminate in many cases the need for machining on all except the wear and contact surfaces. Surface finish is such that fine engraving can be duplicated and 250-300 microinch surface finish can be attained under controlled conditions. On some parts where contoured areas formerly required profile milling, shell castings have eliminated the need for this costly machining operation. For example, prior to the advent of shell molding, the trigger housing of the Browning automatic rifle, Fig. 2, was machined all over. Even when machining is necessary, overall casting accuracy permits the use of minimum finish stock. This eliminates the need for roughing cuts in most surfaces, and in some cases only a grinding operation is required.

Although the improved casting accuracy obtainable in shell castings generally results in elimination of some machining operations, it is sometimes more practical to machine all over. Here, again, the more accurate shell-molded castings allow for less machining stock and more positive chucking. Furthermore, a cleaner casting surface permits higher cutting speeds, increased production, and increased tool life.

Examples of Production Castings:

GOVERNOR BODY AND BUSHING, Fig. 3: These parts for an automatic transmission were formerly made of aluminum die castings, but the steel piston rings used in conjunction with the aluminum governor body caused excessive wear in the ring grooves. It had not been possible in the past to cast these parts in gray iron because of the difficult coring involved. However, shell molding has made this a relatively simple job to cast, and several million of each part have now been produced.

Of special note is a hole cored completely through the larger casting. The portion of the grooves cast by the core must be in perfect alignment with that made by the cope shell. The minor diameter of the core is 5/16-in.; and this diameter, machined to ⅜-in. by the casting user, obviously allows very little for casting or machining errors.

VALVE BODY, Fig. 4: Complicated parts such as this are easily cast in gray iron. The part was considered as an aluminum die casting, but this was thought unsatisfactory because of adverse expansion and wear characteristics. Meeting the requirements for very close tolerances on the thickness and location of ports was made possible by the shell process.

ADJUSTER NUT, Fig. 5: This is a good example of casting improvement by converting from green-sand to shell molding. In the original design, heavy section thicknesses exceeded strength requirements of the part, but green-sand molding considerations did not permit further lightening of the casting. Draft angles on this green-sand design varied from 2 deg to as much as 10 deg. Further lightening of the part could be accomplished only through the use of cores. The shell-process version uses draft angles of 1 deg or less and has deeper pockets in the areas where excess metal previously existed.

AUTOMOTIVE CAMSHAFT, Fig. 6: Among the advantages of shell-molded camshafts are: (1) better dimensional control for automatic handling; (2) better tool life due to absence of burned-in sand; and (3) cleaner side surfaces on cam lobes, providing freedom from ragged edges.

FLANGE YOKE, Fig. 7: This part has recently replaced a forging of similar design. On the forging, machining operations on the body portion were necessary to provide a balanced part and also to provide clearance for the four bolt holes. The close dimensional control and small draft angles on the shell castings made these operations unnecessary. Because this area does not require machining, it was possible to incorporate ribs which greatly increase the fatigue life of the part. Other advantages of the shell castings are: (1) virtual elimination of pattern-shift problems: (2) a hole provided through the splined tube without the use of a core; (3) sharper detail and well-filled-out corners and edges: and (4) increased tool life, resulting in less down-time for tool changes.

TRANSMISSION DRUM, Fig. 8: In this application, machining on clearance dimensions has been eliminated, and balance drilling has

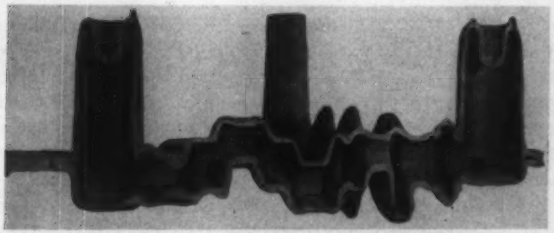


Fig. 1—Section through an assembled shell mold. Shell thickness varies from 3/16-in. to approximately 9/16-in., depending upon physical characteristics of the casting and type of metal being poured.

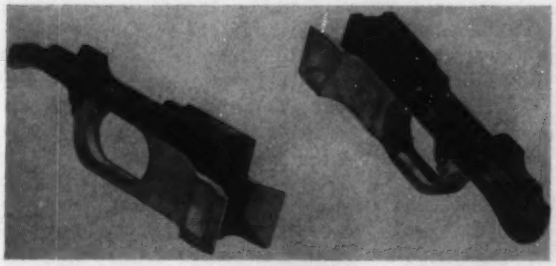


Fig. 2—Shell-molded trigger housing of Browning automatic rifle. Machining is required only on the wearing surfaces indicated by dark paint.

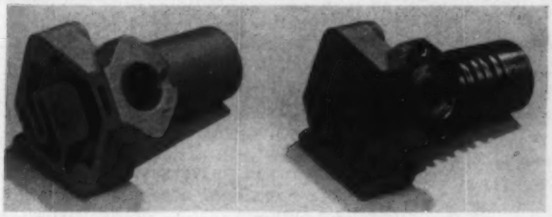


Fig. 3—Governor body casting, left, and the same casting machined, with a bushing in place, right. Nominal machining stock allowance on these parts is 1/32-in.

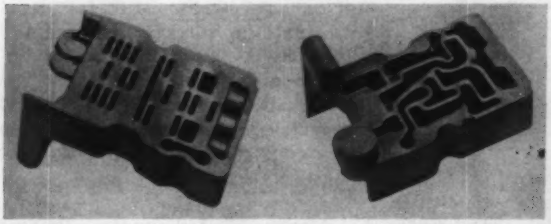


Fig. 4—Valve body for the automatic transmission of a military vehicle. A dimensional tolerance of ±0.005-in. per in. is conventional for small shell castings.

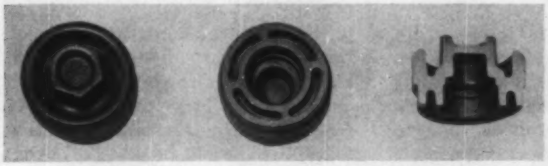


Fig. 5—Adjuster nut for conventional steering gear. In this shell-process version the weight has been considerably reduced from the earlier design for sand casting, machining stock is less, and the hexagonal portion for wrench application is more accurate.

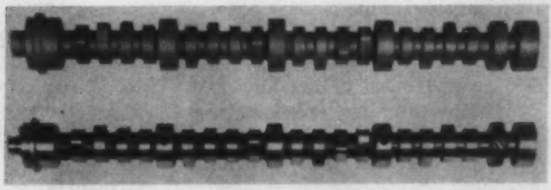


Fig. 6—Shell-molded automotive camshaft notable for less scrap than conventional castings, shown here before and after machining.

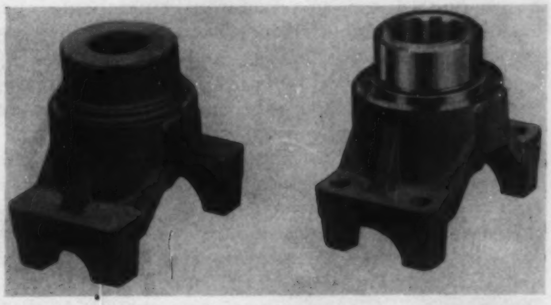


Fig. 7—Shell-molded ArmaSteel flange yoke used on an automotive propeller shaft. This casting eliminates machining on the outside and inside surfaces of the body portion.

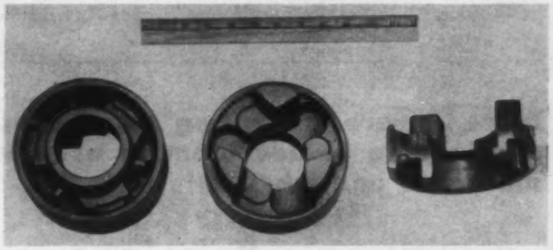


Fig. 8—Automatic automotive transmission drum. Produced by the shell process, it offers a wider latitude of design than drums made by other methods.

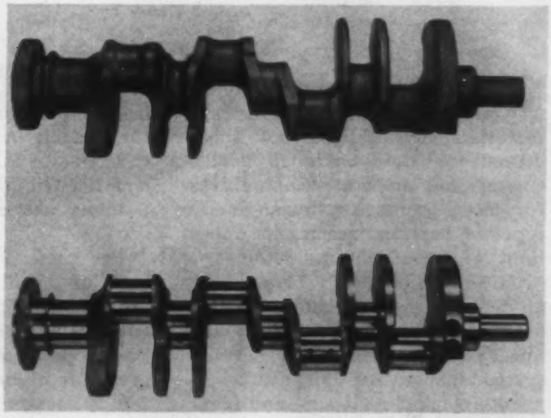


Fig. 9 — Automotive crankshaft molded by the shell process, showing shell-molded ArmaSteel casting before machining, weight 64 lb, top, and after machining, weight 54 lb, bottom.

been greatly reduced. The conversion of this part from green-sand molding to shell molding was justified on the basis of machine savings alone. Further, freedom from surface sand is important because the part operates in a hydraulic medium.

AUTOMOTIVE CRANKSHAFT, Fig. 9: The production of automotive crankshafts by the shell process has permitted car manufacturers to increase maximum horsepower through increasing piston size and length of stroke without major changes in any of the other engine parts. This has proved to be a great advantage to engine designers when dealing with problems caused by the restricted space in the crankcase area. These modifications result in greater rotating and reciprocating forces which, in the modern V-8 engine, must be balanced by larger counterweights. Now the problem is solved with relative ease, for the shell-molding process allows considerably greater latitude in design of the counterweights.

With a shell-cast crankshaft, it is possible to flare the counterweights to any desired width (end surfaces can be practically perpendicular to the pattern parting) to achieve the maximum balancing effect. Radii of counterweight tips can be consistently cast as low as $\frac{1}{8}$-in. (In other methods of producing crankshafts, the variation on the tips or corners was so great that a 1-in. radius was usually specified.) Shell-cast crankshafts are produced with extremely narrow spaces between the counterweights, inasmuch as the drawing of deep and narrow pockets of this nature is now quite practical. Another advantage is that draft angles of less than $\frac{1}{2}$-deg are commonly used. All these factors make it feasible to produce the eight-counterweight shafts, which many engineers favor because of their ability to decrease crankshaft deflection and main-bearing loads. With shell-cast ArmaSteel (pearlitic malleable iron), crankshafts can now be made even for the extremely difficult V-6 engine.

From the standpoint of machining, shell-cast ArmaSteel crankshafts present substantial savings. On some designs, it is possible to eliminate the cheeking on the sides and the turning operations on the outside diameters of the counterweights. When these machining operations are necessary to attain maximum counterweight thickness and diameter, only a minimum of stock need be removed.

Good dimensional control of shell-cast crankshafts over long production runs provides for consistent balance drilling and has permitted the removal of 44 per cent of the machining stock required on the forging previously used. This dimensional control is due to the negligible pattern wear and the hard, smooth, accurate mold. Through the use of accurately machined patterns, with crankpins positioned, the completed castings provide excellent crankpin index.

From a paper entitled "Shell Castings" presented at the ASME Annual Meeting in New York, November, 1956.

More severe operating conditions are leading to development of new materials and lubricants for . . .

Bearings

By E. G. Jackson and E. R. Booser
General Electric Co.
Schenectady, N. Y.

MAXIMUM temperature tolerable to bearing and lubricant materials at localized hot spots establishes the maximum loads, speeds, and ambient temperatures for most bearing systems. Many types of bearings reach this upper limit at about 250 to 300 F.

Other limiting factors are the lubricant's chemical and physical stability. They not only fix the upper temperature of a bearing system's operation but also complicate machinery design and manufacture. In short, allowances must be made for periodic lubrication with fresh oil or grease.

Today, in well over 90 per cent of industrial sleeve and thrust bearings, babbitt metal constitutes the bearing material. This material remains unsurpassed for excellent low-friction, antiscoring, antiwelding, and dirt-embedding qualities.

The metal's upper temperature limit of 250 F, now being pushed, is reached in some gas turbine, automotive, and diesel applications. Thus, vigorous search is in progress for higher-temperature bearing materials. Such bearing alloys as aluminum, bronze, nickel and also pure silver, Table 1, are being used in high-temperature applications. As yet though, none has proved as versatile as babbitt.

Conventional steels used in ball and roller bearings have a similar temperature limit of about 250 to 300 F. With special heat-treating procedures, this limit can be raised to about 400 F — still far from adequate in aircraft jet engines. Neither is this adequate for instruments, accessory drives and other devices in missiles and rockets—nor for that matter, even in industrial units operating at high temperatures.

Limits of Lubricants: Present lubricants are limited at least as severely as bearing materials. The best petroleum oils begin to oxidize rapidly at temperatures above 225 to 250 F. Varnish, sludges and corrosive agents then form in the oil. Furthermore, these lubricants usually don't have the needed viscosity for the temperature range of -65 to $+300$ or 400 F. If they are thick enough at the high-temperature end, then they're too viscous at the low end.

In industrial devices, greases frequently lubricate ball or roller

Designing the wheels of their unique "Kompactor" with Lukens heads enabled The Buffalo-Springfield Roller Co., Springfield, Ohio, to simplify construction, save costs, and give new efficiency to huge self-propelled road rollers. Is there an idea here for you?

Imagination pays off... when you design with Lukens Heads

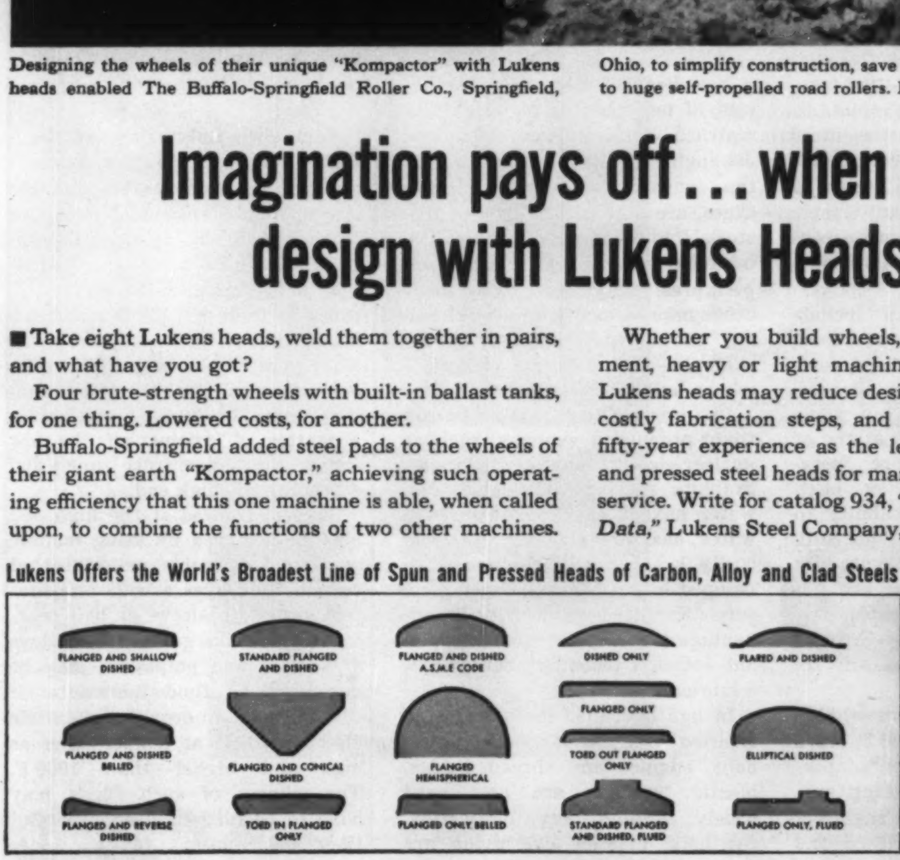
■ Take eight Lukens heads, weld them together in pairs, and what have you got?

Four brute-strength wheels with built-in ballast tanks, for one thing. Lowered costs, for another.

Buffalo-Springfield added steel pads to the wheels of their giant earth "Kompactor," achieving such operating efficiency that this one machine is able, when called upon, to combine the functions of two other machines.

Whether you build wheels, valves, chemical equipment, heavy or light machinery, imaginative use of Lukens heads may reduce design complexity, eliminate costly fabrication steps, and raise efficiency. Lukens' fifty-year experience as the leading producer of spun and pressed steel heads for many applications is at your service. Write for catalog 934, *"Pricing and Engineering Data,"* Lukens Steel Company, Coatesville, Pa.

Lukens Offers the World's Broadest Line of Spun and Pressed Heads of Carbon, Alloy and Clad Steels


FLANGED AND SHALLOW DISHED
STANDARD FLANGED AND DISHED
FLANGED AND DISHED A.S.M.E CODE
DISHED ONLY
FLARED AND DISHED
FLANGED ONLY
FLANGED AND DISHED BELLED
FLANGED AND CONICAL DISHED
FLANGED HEMISPHERICAL
TOED OUT FLANGED ONLY
ELLIPTICAL DISHED
FLANGED AND REVERSE DISHED
TOED IN FLANGED ONLY
FLANGED ONLY BELLED
STANDARD FLANGED AND DISHED, FLUED
FLANGED ONLY, FLUED

LUKENS ®

Circle 454 on page 19

Table 1—Temperature Limits for Bearing Materials

Materials	Maximum Useful Temperature (F)
Journal Bearings	
Babbitt	250
Aluminum	400
Bronze	500
Silver	600
Nickel alloys	1600
Cobalt alloys	1600
Ceramics	2000
Rolling Bearings	
Special ball-bearing steel	400
Medium alloy steels	600
High alloy high-speed tool steels	800

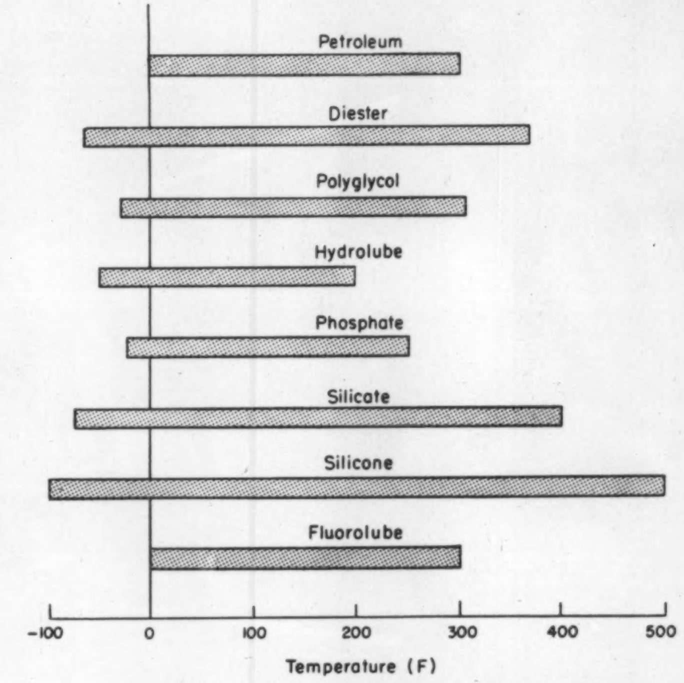


Fig. 1—Useful temperature range of lubricants.

bearings. Greases — simply oil thickened with some gelling agent such as soap—have the same temperature limitations as oils. In fact, they are even more restricted because both the gel structure and the fluid have to resist heat. Generally speaking, temperature limits of greases used in electric motors, instruments, and appliances are 50 to 100 degrees less than those of the fluid lubricants from which they are made.

Initial steps beyond natural mineral oils have, in fact, already been taken to produce synthetic oils. These have raised the limiting temperature of lubricating oils to around 500 F, Fig. 1. In the latest jet engines for example, compounded synthetic oils remain stable to 400 F or more. Additionally, their viscosity within the temperature range varies less than that of natural oils.

These new synthetics include polyesters, synthetic hyrocarbons, chlorinated hydrocarbons, polyethers, silicate esters and silicones. All have disadvantages in some characteristics: large variations of viscosity with temperature; instability in the presence of heat, oxygen, or water; or inability to provide boundary lubrication. Still, one or more of these synthetics can probably be modified and adapted to carry conventional bearing systems to 600 or 700 F if the lower temperature limits are relaxed.

Known fluids with a temperature range of −65 to +700 F have been about exhausted for adaptation to conventional bearing systems. And so, bearing engineering of the future will heed the limits of fluid lubricants.

New Bearing Materials: The advent of new bearing materials has matched lubricant developments. Jet-engine bearings, more or less the conventional ball and roller types, are now being made of tool steels that maintain the necessary hardness and strength at high temperatures. Engineers have made other improvements, too, by choosing plating materials—silver, for example—that lubricate easily for use on ball and roller separators.

In applications other than flight-propulsion systems, such as nuclear-electric power stations, graphite bearings lubricated with water have been successful. True, water has an extremely low viscosity but becomes effective when pumped into a bearing under pressure. Furthermore, it has the advantage of being an excellent coolant—often a secondary function of a lubricant.

In lightly loaded mechanisms as typified by clocks, instruments, baby buggies and thread guides, plastic bearings are now used widely without any lubrication. Synthetic plastics like nylon are particularly useful in such applications because of their low coefficients of friction.

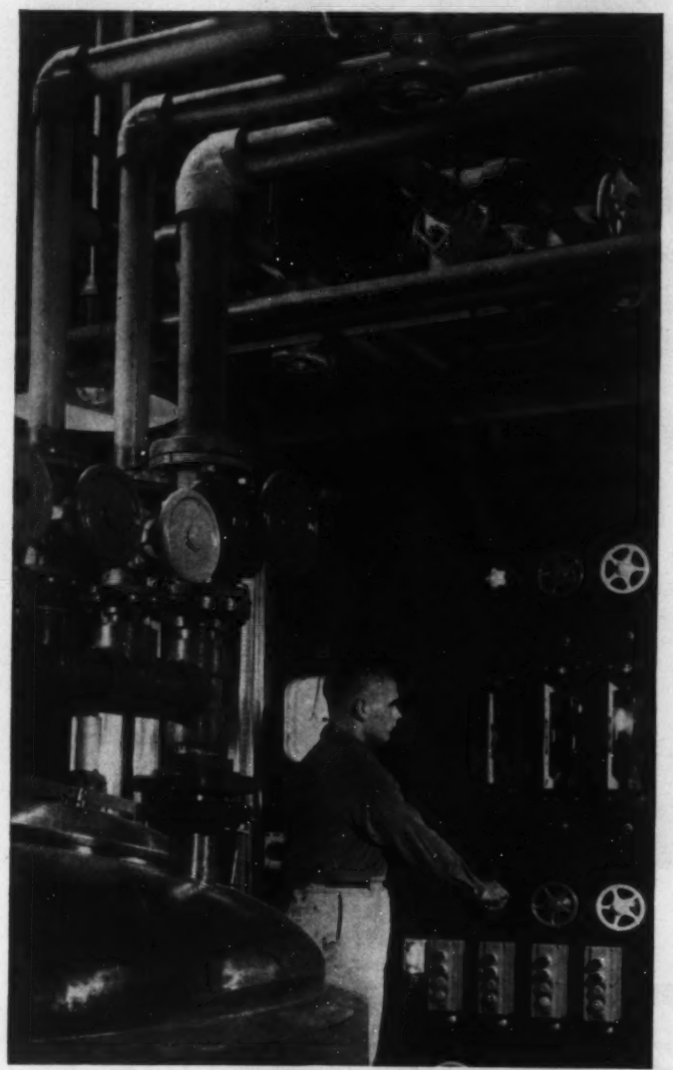
Tomorrow's Lubricants and Bearings: Design of bearing systems will become more flexible with the introduction of new materials and lubricants. Then too, design specifications will be modified. Elimination of the requirement that lubricants be fluid at −65 F and heating of the oil where necessary will make possible the use of lubricants more viscous at the highest temperatures. In other words, it is a matter of cutting off the low end of the temperature range and extending the high end.

These advances at the high end may be achieved by using molten, or chemically stable, materials that remain fluid over a wide temperature range. In sleeve or ball bearings metals like gallium and alloys of sodium and potassium may be developed as fluid lubricants.

A few new organic materials also are stable at temperatures as high—and higher—than 1000 F. The oiliness of such fluids may have to be further developed. But their use appears feasible, once

Another new development using

B.F.Goodrich Chemical *raw materials*



purity was the problem...

GEON VINYL

solved it!

SINCE the fine chemicals processed in this plant react with metallic piping, and thus acquire impurities, a new material was needed.

Piping made from Geon rigid vinyl resin was the logical solution. This durable pipe does not react with the chemicals it carries. It offers superior resistance to oils, acids, alkalis, and most chemicals.

Rigid vinyl pipe of Geon was the *economical* solution too. It weighs only one-fifth as much as steel pipe of similar size, simplifying handling and shipping. It's easily installed, since pipe and fittings are joined quickly with solvent cement.

Geon is a remarkably diverse family of polyvinyl materials . . . star performers for rigid products like piping, valves, housings . . . flexible wall coverings, weatherstripping, foam products . . . coatings for steel, paper, or textiles. One member of the Geon family can surely help *you* make a better product, offer a better value. For information write Dept.DO-3, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

Rigid vinyl piping *at the Rebeis Company, Inc., Berkeley Heights, N. J., handles fine chemicals used in many leading pharmaceutical and cosmetic products. Pipe and fittings for this installation were manufactured by Alpha Plastics Inc., Livingston, N. J.*

A TRADE MARK OF B. F. GOODRICH CHEMICAL COMPANY

Geon

Polyvinyl Materials

A DIVISION OF THE B. F. GOODRICH COMPANY

B.F.Goodrich Chemical Company
a division of The B.F.Goodrich Company

B.F.Goodrich **GEON polyvinyl materials • HYCAR American rubber and latex • GOOD-RITE chemicals and plasticizers • HARMON colors**

engineers stop insisting that lubricants be fluid at ordinary temperatures.

To utilize such fluids, ball bearings need more strength and fatigue resistance. The high pressure—and its cyclic application—that ball bearings are subjected to poses the real problem. Even the high-speed tool steels obtainable today lose strength rapidly at 1000 F. Perhaps acceptable substitutes may crop up among the sintered carbides (used for cutting tools), intermetallic compounds, newer alloys or even ceramics.

Fatigue presents less of a problem in sleeve bearings. For these another type of lubricant may be adopted. Where a hydrodynamic barrier—or pressurized fluid film—is utilized, sleeve bearings require of their lubricants only viscosity. And the faster the shaft turns or the narrower the clearance between shaft and bearing, the less viscosity required.

Carried beyond ordinary extremes, this can be interpreted to mean that gaseous lubricants are feasible. While air or steam as fluids may be low in viscosity, they have thermal and oxidation stability. Instead of decreasing with temperature, their viscosity improves, Fig. 2.

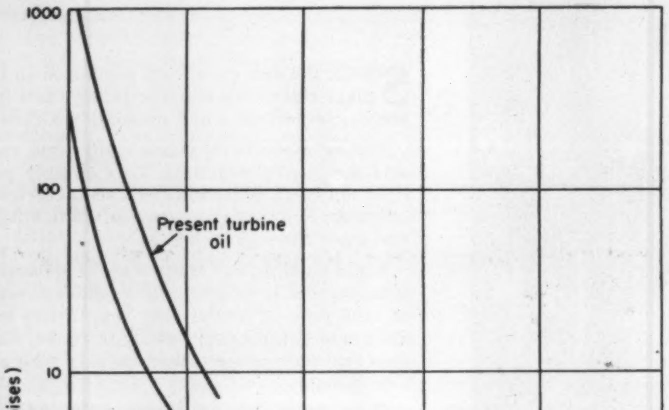


Fig. 2—Viscosity of several materials compared with air and steam at temperatures from 0 to 1000 F.

Naturally, the use of steam as a lubricant is highly attractive to engineers designing steam turbines. A readily available product, it reduces fire hazards and problems of sealing. An electric motor with its rotor turning and supported in air may be developed. The stator would be the only bearing. With heavy loads, the high-pressure air from an auxiliary compressor could also be used to float the rotor on air.

These are fanciful schemes. Whether they will prove practicable depends on the magnitude of the technological problems they impose. For example, at temperatures of 1000 or 2000 F, air and steam may corrode bearing materials.

The close clearance would require fine alignment. And the failure of the air or steam supply would immediately result in dry welding of the bearing surfaces.

How will these difficulties be surmounted? Perhaps the answer lies in the development of more efficient dry lubricants. With these, in fact, all other lubricant problems, such as chemical stability and the changes that occur in viscosity, could be eliminated.

Dry lubricants like graphite and molybdenum disulfide already satisfy some slow-speed applications. However, they do not form self-renewing boundary layers the way fluids do—a principal disadvantage. Eventually this results in loss of lubrication on the worn areas and, inevitably, failure. Needed to offset this disadvantage is an extremely tenacious dry lubricant coating or, lacking that, a means of continually rebuilding the boundary layer.

The first steps toward such lubricants have already been taken. Powdered molybdenum sulfide and graphite dusts, fed into rotating ball bearings by air stream, have successfully lubricated the bearings at temperatures as high as 1000 F.

Other dry materials — one of these, boron nitride—also exhibit lubricity, that is, form boundary layers. A dry lubricant even more effective than graphite will possibly be discovered in the future.

From "Bearings — How They'll Be in the Future" in General Electric Review, *November,* 1956.

BIG FORGINGS to help make other forgings

These three forgings have a strong family tie, since they were all made in the Bethlehem shops for use in the same machine. That machine, by the way, is a mechanical monster whose job is to make more forgings. It exerts tremendous pressures, so the components you see in the picture have their work cut out for them.

In the foreground, looking very much like a giant potato-masher, is a pullback cylinder; length, 13 ft 8 in. The OD of the main body ranges from 43 to 46 in. Weight of piece as shown, 26,550 lb.

The twin forgings in the background are intensifier cylinders. Each has a maximum OD of 58 in. and an overall length of 7 ft 11 in. Each weighs 27,640 lb. Thus, though the camera may have fooled you, these pieces are actually somewhat heavier than the pullback cylinder.

You may never require any forgings of quite the same nature. Perhaps your needs run to much smaller items, or to something much larger. In any case, Bethlehem is fully prepared to take care of you. Our shops can meet your specifications on all types of drop, press, and hammer forgings, regardless of size or design. Inquiries always welcomed.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by
Bethlehem Pacific Coast Steel Corporation
Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

Circle 456 on page 19

Helpful Literature

for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Magnesium & Titanium

Physical and mechanical properties, metal weights, forming characteristics, specification tables, corrosion behavior, surface treatments, welding and joining, machining, heat treatment, stress relief and other design data for magnesium and titanium are content of technical design booklet. 44 pages. Brooks & Perkins, Inc.

Circle 551 on page 19

Production Facilities

Among services and facilities outlined in illustrated catalog are the welding of aluminum and making of experimental sheet metal stampings from light gage aluminum and heavy gage steel. Other operations include die models and plastic duplications, short run stampings, zinc alloy dies and handmade samples. 12 pages. Automotive Fabricators Inc.

Circle 552 on page 19

Tube Fittings

Catalogs 4310 and 4320 respectively describe Triple-lok and Ferulok tube fittings. Former is leakproof even under high pressure, severe vibration and extreme temperatures. Latter fitting is a flareless "bite" type suitable for extra heavy wall tubing. 52 and 28 pages. Parker Appliance Co., Tube & Hose Fittings Div.

Circle 553 on page 19

Measuring Process Variables

ElectroSyn system for precisely measuring pressure, differential pressure, flow, liquid level and temperatures is described in bulletin B 527. A signal transmitter, power unit and a null-balance indicating receiver are included. 4 pages. Detroit Controls Corp., Norwood Controls Unit.

Circle 554 on page 19

Control Switches

Water and oil-tight Gold-N-Ring Sealtight heavy-duty pilot control units for use on machine tools or any equipment using cutting or lubricating fluids are described in brochure. Pushbutton and selector units, pilot light, control stations and accessories are covered, as well as limit switches and solenoids. 12 pages. National Acme Co.

Circle 555 on page 19

Electric Starter

The Fairbanks-Morse electric starter for pushbutton starting of small gasoline engines is available for either battery or 110-v ac operation. Details are provided in bulletin FM273A. 4 pages. Fairbanks, Morse & Co.

Circle 556 on page 19

Impulse Counters & Transmitters

Swiss bulletin describing Sodeco Ti series of predetermined electric impulse counters and impulse transmitters gives physical properties of various models, including the Sodeco preselection counter designed for automatic recycling of counting runs. 8 pages. Landis & Gyr, Inc.

Circle 557 on page 19

Turns Counting Dial

The Digidial, a digital turns-counting dial, reads directly in full turns, tenths and hundredths. No interpolation is necessary. Described in data sheet 54-91, dial can be read from 6 ft away and at extreme angles. 4 pages. Helipot Corp.

Circle 558 on page 19

Vinyl Covering Material

File folder 15-M provides actual color samples of Duran Clad, a semirigid vinyl that can be laminated to sheet metal or continuous coils, then formed into product components. 4 pages. Masland Duraleather Co.

Circle 559 on page 19

Teflon Rod

Properties, specifications and prices of TSI Teflon rod are given in bulletin T-257-R. Forty diameters are now available, ranging from 0.125 to 1.000-in. Prices show reductions of up to 30 per cent. 2 pages. Tri-Point Plastics, Inc.

Circle 560 on page 19

Deburring Brushes

Folder COC 290 highlights the Osborn Matic and Tufmatic industrial brushes. Former will maintain precise brushing action under rigorous continuous use, while latter, designed for stronger action, will remove burrs and scale. Folder shows on-the-job applications and gives specifications. 4 pages. Osborn Mfg. Co.

Circle 561 on page 19

Aluminum Coated Steel

"Where Designers Use Armco Aluminized Steel Type 1" is an illustrated bulletin that covers heat reflectance, heat and corrosion resistance, strength, and reduced costs. Typical applications are covered, as are fabricating techniques. 6 pages. Armco Steel Corp.

Circle 562 on page 19

Press Conveyors

Rapistan Press-Veyor, Jr. and the new magnetic Press-Veyor belt conveyor for moving stampings or scrap from press to tote bin are described in product bulletins LPV-56 and MPV-56. Latter unit keeps material on inclined belt by means of a magnetic field. 2 pages each. Rapids-Standard Co.

Circle 563 on page 19

Static Switching Systems

What is believed to be the first application of static switching in the steel industry is described in bulletin GEA-6364. System is installed on a four-stand tandem cold mill at the Youngstown Sheet & Tube Co. 8 pages. General Electric Co.

Circle 564 on page 19

Miniature Threading Tools

Line of miniature taps and dies for 56 to 160 threads per inch, twist drills from No. 37 to 80 sizes and screws and nuts in 56 to 160-thread per inch sizes are subject of illustrated bulletin. Specs are given. 4 pages. J. I. Morris Co.

Circle 565 on page 19

Permanent Magnets

Magnetic and mechanical properties, approximate tolerances, magnet assemblies and ordering information on cast Alnico 5 and sintered Alnico 2 permanent magnets are contained in catalog PM-121. Bars, horseshoes,

HOWELL MOTOR BRIEFS

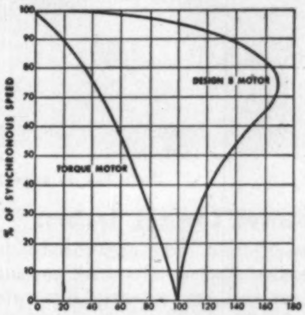
Quick facts for those who apply and specify electric motors

Torque Motors: *They Stall and Hold*

If you want a machine drive to not only apply power but also hold a position or maintain a constant tension, a Howell torque motor may be your solution. Here's a motor that can be stalled, while exerting maximum torque for predetermined intervals, without burning out . . . that can also apply virtually constant torque while operating at a given sub-synchronous speed.

Linear Speed-Torque Curve

The graph below shows this motor's almost linear speed-torque characteristics as compared to a conventional motor's. The secret lies in the design, which produces increased torque while limiting locked rotor current.



Adaptable to Many Uses

In addition to the clamping, elevator drive and reel tension applications shown at right, Howell torque motors are doing a great many other jobs. Door opening and closing, take-up reeling of film and carbon paper, activating electrical starter contacts and a variety of clutching, chucking and braking operations are among them. They do a quieter, more positive job than many mechanical devices and can often effect important simplifications in machine design.

Typical Howell Series 100 Torque Motor

Write us details of *your* requirements. We'll be glad to make suggestions and a quotation.

Two Howell Torque Motors operate clamps for positioning and holding the workpiece on this high-speed, automatic milling and centering machine. Seven Howell motors in all provide power for this precision operation.

A Howell Torque Motor operates the brake and the elevator driving mechanism shown at right. Opening and closing of elevator doors is another typical torque motor application.

A constant, precise tension is maintained on monofilament plastic thread, after extrusion, by the 36 Howell Torque Motors on this winding machine. Multi-speed reeling and winding operations, particularly, are simplified by the use of torque motors in place of geared mechanical devices that are relatively expensive and difficult to keep in adjustment.

HOWELL MOTORS

HOWELL ELECTRIC MOTORS COMPANY, HOWELL, MICHIGAN

PRECISION-BUILT MOTORS FOR INDUSTRY SINCE 1915

Circle 457 on page 19

disks, rotors, U's and sleeves are among the shapes described. 12 pages. General Electric Co., Metallurgical Products Dept.

Circle 566 on page 19

Proximity Switch

Detection is accomplished by the 1FA1 proximity switch by an object passing through a magnetic field in front of its sensing end. Description, applications, installation and performance data are given in data sheet 119. 2 pages. Minneapolis-Honeywell Regulator Co., Micro Switch Div.

Circle 567 on page 19

Plastic Closures

File folder contains data sheets on expanded line of CaPlug polyethylene closures, used to protect tubing, valves, hydraulic components, machined parts and fittings. Samples are included. Protective Closures Co., CaPlugs Div.

Circle 568 on page 19

Variable Pitch Drives

Three illustrated bulletins present descriptive data and specifications for variable pitch sheaves with fixed centers, compound variable speed drives for low speed applications and a drill press drive. 8, 4 and 2 pages. Speed Selector Inc.

Circle 569 on page 19

Electric Motors

Line of single phase, polyphase and direct current ½ to 30-hp electric motors is subject of illustrated bulletin SDA 155. Various types of fractional and integral horsepower motors, enclosures and mountings are covered. 8 pages. Peerless Electric Co.

Circle 570 on page 19

Electronics Equipment

Described and illustrated in general catalog are power and electronic circuit relays, electronic flashers, time delay relays, sequence timers, over and under voltage and frequency sensors, and voltage regulators. Electronic Specialty Co.

Circle 571 on page 19

Repeat Cycle Timers

Function of three basic miniature repeat cycle timers is detailed in illustrated bulletin AWH RC201. Dimensions for ac, dc and 4-cycle units with cycling times from 1 to 23 hours are given. 2 pages. A. W. Haydon Co.

Circle 572 on page 19

Threaded Blind Rivets

Applications, preparation procedures, and much other technical data on Rivnuts, one-piece blind rivets with internal threads, are detailed in data book for designers and engineers. They are used with a hand or power heading tool. Slide type demonstrator shows how they work. 12 pages. B. F. Goodrich Co., B. F. Goodrich Aviation Products Div.

Circle 573 on page 19

Magnetic Tapes

SiFeMag silicon iron magnetic tapes, available in 1, 2, 4, 5 and 7-mil thicknesses, are subject of bulletin DMF-4. They are slit to specifications. Applications, weights, tolerances, insulation, properties and other data are included. 4 pages. Thomas & Skinner, Inc.

Circle 574 on page 19

Transformers

Over 700 transformers, including 117 new models, are described and illustrated in general catalog TR-57. New items include toroids, pulse, transistor, hermetically sealed, geophysical, power, filament and audio transformers; chokes and television components. Triad Transformer Corp.

Circle 575 on page 19

Magnet Wire

Trade name designations used by 20 magnet wire manufacturers are included in directory. It also gives a brief general description of physical, chemical and electrical characteristics and applications common to the ten general classifications of magnet wire. 16 pages. Essex Wire Corp.

Circle 576 on page 19

Cast Iron

Summary of cast iron specifications is offered as folder or with metal grommet on heavy paper for hanging on a wall. Specs for cast pressure pipe, soil pipe, valves and fittings are also summarized. Various specifying groups or associations are listed. 4 pages. Gray Iron Founders' Society, Inc.

Circle 577 on page 19

Couplings

Extensive line of quick-connect fluid line couplings for many services is subject of illustrated catalog. Covered are units for pressure and vacuum, pneumatic, hydraulic, oxygen, acetylene, steam and gas and liquid service. Specifications for all units are given, along with data on hose clamps. Over 44 pages. Hansen Mfg. Co.

Circle 578 on page 19

Air Motors

"The Bellows Air Motor—What it is, How it works, What it does" is an illustrated bulletin (BM-25) that relates the use of this device in automation. Various application examples are shown. The several models made are described. 20 pages. Bellows Co.

Circle 579 on page 19

Printed Circuit Plastic

Cirprint copper-clad laminated plastic for printed circuits can be cold punched up to 1/16-in., is translucent and moisture resistant and has insulation resistance up to 250,000 megohms. Described in illustrated bulletin, it is offered in 1/32 to ¼-in. thicknesses. 4 pages. Formica Corp.

Circle 580 on page 19

Panel Meters

Wide variety of alternating and direct current panel meter types in sizes from 1½ to 4½ in. are described and illustrated in bulletin DL-C-631. Styles include front-of-board, semiflush and flush with standard or hermetic enclosure. Various shapes and case materials are offered. 12 pages. Texas Instruments Inc.

Circle 581 on page 19

Adhesives, Coatings, Sealants

Descriptions and applications for extensive line of adhesives, coatings and sealants are content of illustrated bulletin 7/An. Uses, characteristics, color, base, solvent, viscosity and other data are given for each product. 8 pages. Interchemical Corp., Angier Adhesives Div.

Circle 582 on page 19

Thermoplastic Resin

Properties of Lexan molding compound, a polycarbonate resin, are detailed in folder CDD-3. It has high impact strength and good dimensional stability, heat resistance and electrical properties. Applications are listed. 4 pages. General Electric Co., Chemical Development Dept.

Circle 583 on page 19

Fractured Race Bearings

Explanation of Fractured Race technique of ball bearing making is given in catalog 57. Bearing's outer ring is fractured at one point to allow introducing a maximum complement of balls. Radial, thin section single and double row, and ultra precise thin section bearings are

AVOID the HIGH COST and difficulty of fabricating long, hard & straight parts by conventional methods . . .

THOMSON

60 Case hardened and ground

SHAFTS, ROLLS, GUIDE RODS and other long-round parts

60 Case is the result of over ten years of experimental work and production experience with hardened and ground shafts which are a requirement for BALL BUSHINGS, the Linear Ball Bearing manufactured by Thomson Industries, Inc.

The special techniques and equipment that have been developed enable high production rates and low handling costs. This permits big savings over conventional methods which are plagued with erratic warpage, straightening and resultant grinding problems. Finished *60 Case* parts frequently cost less than the scrap losses that result from conventional methods.

60 Case material has a surface hardness close to 60 on the Rockwell C scale which is essential to resist wear.

Long lengths of material ranging in diameter from ¼" to 4" are stocked to enable prompt shipment of *60 Case* parts, with or without special machining.

Write for literature and name of your local representative

For emergency needs call collect MAnhasset 7-1800

ADVANTAGES of *60 Case*

- COST REDUCTION
- HARD BEARING SURFACE
- ACCURATE DIAMETERS
- GROUND FINISH
- STRAIGHT PARTS
- DELIVERY FROM STOCK
- ADDED STRENGTH
- UNIFORM HIGH QUALITY

TYPICAL *60 Case* PARTS

GUIDE RODS, SHAFTING, ROLLS, TRAVERSE RAILS, PISTON RODS, ARBORS, LEADER PINS, TIE RODS, KING PINS, AXLES, CONTROL RODS, GUIDE POSTS, MANDRELS, BEARING ROLLERS, SPINDLES

THOMSON INDUSTRIES, Inc.
Dept. C-5, Manhasset, New York

Circle 458 on page 19

described. 26 pages. Split Ballbearing Corp.

Circle 584 on page 19

Aluminum Appliance Parts

Examples of the many appliance parts fabricated of aluminum with various finishes are shown in descriptive brochure FP-104-B. Company's fabricating service is detailed. Parts include those for washers, stoves, pans, refrigerators and air conditioners. 24 pages. Reynolds Metals Co.

Circle 585 on page 19

Aircraft Hose & Fittings

Reference catalog 101 covers 666 Teflon hose with "super gem" fittings, plus low, medium and high pressure hoses with detachable, reusable fittings for air, water, fuel, lube and hydraulic applications. Answers to fluid line problems are provided. 88 pages. Aeroquip Corp.

Circle 586 on page 19

Hydraulic Pumps

Balanced Vane hydraulic pumps for continuous 2000-psi service are described and illustrated in bulletin 200. Applications, construction data, and performance information are covered. 8 pages. American Brake Shoe Co., Denison Engineering Div.

Circle 587 on page 19

Tubing & Pipe

Description of 17-7PH stainless steel tubing and pipe, plus analysis, recommended uses, typical mechanical properties, corrosion resistance, workability and hardening characteristics are found in bulletin T.D. 122. 4 pages. Carpenter Steel Co., Alloy Tube Div.

Circle 588 on page 19

Spring Washer Assemblies

Preassembled stacks of multiple spring washers held together by pins or rivets passing through them comprise the compact energy "cartridges" which can be incorporated as one-piece components in the final machine. Bulletin shows assembly and typical applications. 6 pages. Associated Spring Corp.

Circle 589 on page 19

Electrical Testers

Test equipment for servicing electrical equipment, appliances and heating equipment are described in bulletin 2058. New instruments covered include a Low-Ohm-Meter and a millivolt-meter. 6 pages. Simpson Electric Co.

Circle 590 on page 19

Stud Welding

"The Nelwelder" is a regular publication on the applications of stud welding to equipment. This bulletin will be sent regularly to design and engineering personnel interested in stud welding and its potentials. 4 pages. Gregory Industries, Inc., Nelson Stud Welding Div.

Circle 591 on page 19

Textured Plastic Material

Lasting, colorful, textured surfaces are obtainable with Nelam vinyl plastic which is laminated to metal, wood or other materials by Marvibond process. Laminations can be processed or fabricated without damaging the plastic. Full details and samples of Nelam laminates are contained in folder. 4 pages. North East Laminates, Inc.

Circle 592 on page 19

Flexible Connectors

Bulletin 158 on Flexon flexible connectors for pumping installations tabulates size information for easy ordering. Connectors absorb vibration, dampen noise, reduce piping failure and prevent leakage. 2 pages. Flexonics Corp.

Circle 593 on page 19

Stainless Steel Clamps

Specifications and details of Sure-Tite stainless steel clamps for plastic pipe are given in bulletin PP-1256-15. These screw-actuated band clamps are available for diameters up to 7 in. 2 pages. Wittek Mfg. Co.

Circle 594 on page 19

Plastic Pressure Tubing

Characteristics and installation advantages of Nylaflow flexible polyamide pressure tubing are listed in bulletin BR-3A. Two types are available in ⅛ to ⅜-in. sizes for pressures to 1000 and 2500 psi. 4 pages. Polymer Corp. of Pennsylvania.

Circle 595 on page 19

Right Angle Bevel Gears

ANGLgear right angle bevel gear units for industrial use are made in ⅓, 1 and 5-hp sizes. All are available as two-way or three-way types with 2:1 or 1:1 shaft ratios. Bulletin 57 describes these gear units and lists rated horsepower and speed of 12 models. 4 pages. Airborne Accessories Corp.

Circle 596 on page 19

Power Resistors

Suited to electronic and other applications requiring high stability, line of MIL-R-26C power resistors have Vitrohm vitreous enamel construction, wide selection of wattages and resistances and minimum size for their ratings. Details are provided in bulletin 12. 4 pages. Ward Leonard Electric Co.

Circle 597 on page 19

Induction Motors

Design features, performance data, ratings and dimensions of type N integral horsepower induction motors which comply with the new NEMA standards are covered in bulletin PB 6000-6. Totally enclosed, fan-cooled, dripproof and other types are available. 12 pages. Elliott Co., Crocker-Wheeler Div.

Circle 598 on page 19

Electronic Equipment

Typical electronic gear pictured and described in brochure 1-57 includes missile test equipment, automation equipment, vhf transmitters, balloon-code telemetering system, aircraft electronic controls, tape recorders, radar equipment and mobile laboratories. 22 pages. Cook Electric Co., Electronic Systems Div.

Circle 599 on page 19

Oil-Tight Pushbuttons

Oil-Tite pushbuttons for control where liquids are present are described in bulletin B-7022. This guide to custom-made heavy-duty controls deals with types which include cylinder lock, selector switch, indicating light, push-to-test and Navy type lens units. 8 pages. Westinghouse Electric Corp.

Circle 600 on page 19

Small Motor Brushes

"Carbon, Graphite and Metal-Graphite Brushes for Fractional Horsepower Equipment" is title of catalog B-1700 which gives complete engineering, design and application data. Also available is booklet B-1705 on brushes for aircraft equipment. 28 and 6 pages. National Carbon Co.

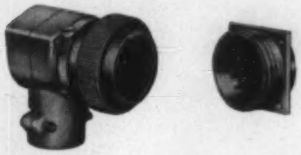
Circle 601 on page 19

Steels

Sixteen categories of special purpose steels, including high speed, tool, stainless, alloy and machinery types available in 16,000 grades and sizes, are included in "Product & Warehouse Catalog." Over 700 products are covered. Other useful data are presented. 232 pages. Request on company letterhead from Crucible Steel Co. of America, Box 1558, Pittsburgh 30, Pa.

K (STANDARD)

For Aircraft, Electronic, Instrument, Military, Missile, Industrial and Commercial Applications.



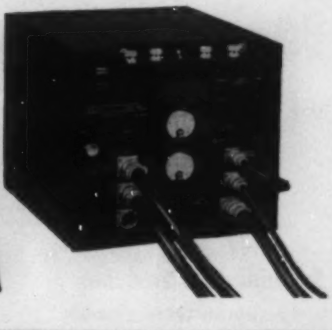
Standard K and RK... in straight and angle 90° plugs, wall mounting receptacles. Conduit and clamp entry types. 1 to 82 contacts in 213 different insert arrangements. 10-, 15-, 30-, 40-, 60-, 80-, 115-, and 200-amp. silver-plated brass contacts. High quality phenolic, melamine, and formica insulators. Cadmium-plated aluminum alloy shells. Flashover voltages: 1100 to 5000v 60cps ac rms.

connect with

CANNON PLUGS

APPLICATION

Application of R and RK connectors on a recording oscillograph.



original aircraft, electronics, sound, and all-purpose line

KH, RKH
(HERMETICALLY SEALED)

For Use Under Critical Pressure and Leakage Conditions

Hermetically sealed connectors... with steel shells, steel contacts, and Canseal glass insulators, fused to shell and contacts. *True hermetic sealing.* Electro tin plating over cadmium plate over copper flash provides highly receptive surface for soldering and corrosion resistance.

STEEL SHELL FIREWALL

For Open Flame Protection Against High Temperatures

FW and FWR Cannon K Firewall Connectors... available in straight and angle 90° plugs, wall mounting receptacles. Inserts of phenolic or fireproof inserts of glass-filled materials. Crimp type contacts. Cannon made the first firewall connector and continues the leader in this important field.

RECORDER CONNECTOR

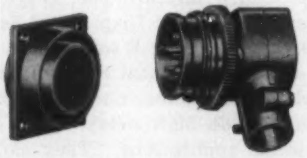
For Telephone "Beeper" Connectors

SK-M7-21C... Widely used on two leading makes of telephone recorded connector units known as "beepers" because of the signal required by law in such recordings.

special acme thread • rugged construction • variety of coaxials • integral clamps

RK
PLUG AND RECEPTACLE

For Flush or Semi-Flush Mounting



RK plug and pin assemblies are equipped with an external threaded coupling nut which is the reverse of the standard K series. Note, RK will not mate with K's.

RLKL and LKL
(TV SWITCHING PANEL)

For TV Panel Switching

Quick Connect and Disconnect RLKL Plugs... designed for one-hand fast disconnect use on TV station program switching panels. Feature a quick coupling means. Latchlock secures plug to mated fitting (RLKL receptacle). Thumb pressure releases it.

K ACCESSORIES

Straight and Angle 90° Junction Shells, Dust Caps, Bonding Rings, Gland Nuts, Clamps, Dummy Receptacles

Featuring High Quality Materials and Workmanship... Junction shells are designed to protect, shield, and carry wires through walls, panels or bulkheads to conduit. Dummy receptacles hold and protect plugs when not in use.

cannon plugs • standard of quality for the industry

TBF-K

For Carrying Circuits Through Bulkheads

TBF-K Bulkhead Connectors... feature a double-faced construction *allowing mating at both ends.* Pin inserts. Single piece shell. Five insert assemblies available.

Other Cannon Series... Mil. Spec. "AN" (full line)—External Power Connectors—Switching Types—dc Solenoids—Guided Missile Launching Connectors—Miniatures and Sub-Miniatures.

See "K" Bulletin
for Engineering Data.

Please Refer to this Magazine or to Dept. 185

CANNON PLUGS

CANNON ELECTRIC COMPANY, 3208 Humboldt Street, Los Angeles 31, California. Factories in Los Angeles; East Haven, Connecticut; Wakefield, Massachusetts; Toronto, Canada; London, England; Melbourne, Australia. Manufacturing licensees in Paris, France; Tokyo, Japan. Contact our representatives and distributors in all principal cities.

Circle 459 on page 19

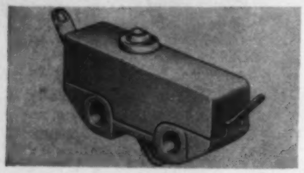
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Subminiature Switches

operate in temperatures from −65 to 250 F

No. 5300 series switches, which measure 25/32 by 17/32 by ¼-in., can be ganged together to perform multiple switching functions in confined areas. Each switch is available according to specifications as single-pole normally open, single-pole normally closed, or single-pole, double throw. Characteristics are 5 amp resistive at 28 v dc and 5 amp resistive at 115 v ac. They operate satisfactorily from −65 to 250 F. **Haydon Switch Inc.**, 536 S. Leonard St., Waterbury 20, Conn.

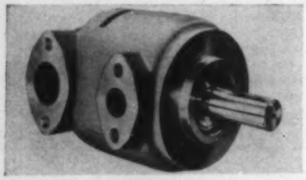


Circle 602 on page 19

Vane Pumps

deliver up to 100 gpm

T Series balanced-vane hydraulic pumps, for continuous 2000-psi service, supply rated deliveries of up to 100 gpm at speeds to 1800 rpm. Pumps are available with either clockwise or counterclockwise shaft rotation. Nose-type shaft seal withstands inlet pressures up to 100 psi. Pumps may be face, foot or flange-mounted in any of four positions on the mounting bracket. Inlet port can be assembled in different positions relative to the pressure port. Units are applicable for earthmoving equipment, special machinery and automation. **American Brake Shoe Co.**, Denison Engineering Div., 1160 Dublin Rd., Columbus 16, O.

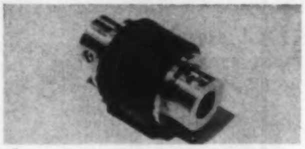


Circle 603 on page 19

Flexible Couplings

in ⅛, 3/16 and ¼-in. diam shaft sizes

Type BH flexible couplings with 303 stainless-steel hubs are precision bored to ±0.002-in. tolerance, and are available in ⅛, 3/16 and ¼-in. diameter shaft centers. Centers are molded neoprene and meet MIL-R-6855. Couplings control shaft-to-shaft misalignment and isolate torsional vibration. They also allow insulation between units. **PIC Design Corp.**, 477 Atlantic Ave., East Rockaway, N. Y.

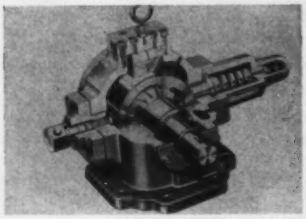


Circle 604 on page 19

Hydraulic Pump

for 1000-psi continuous operating pressure

Model R variable-volume hydraulic pump is suited for use in machine-tool feed systems, hydraulic presses and mobile equipment. It delivers 40 gpm at 1200 rpm, and is for 1000 psi continuous operating pressure and 1250 psi intermittent duty. Pump delivery is manually adjusted to circuit requirements. Automatic selection of two separately adjustable pressures is obtained by using hydraulic or electrically controlled pressure compensating pump governors. **Racine Hydraulics & Machinery Inc.**, 2000 Albert St., Racine, Wis.

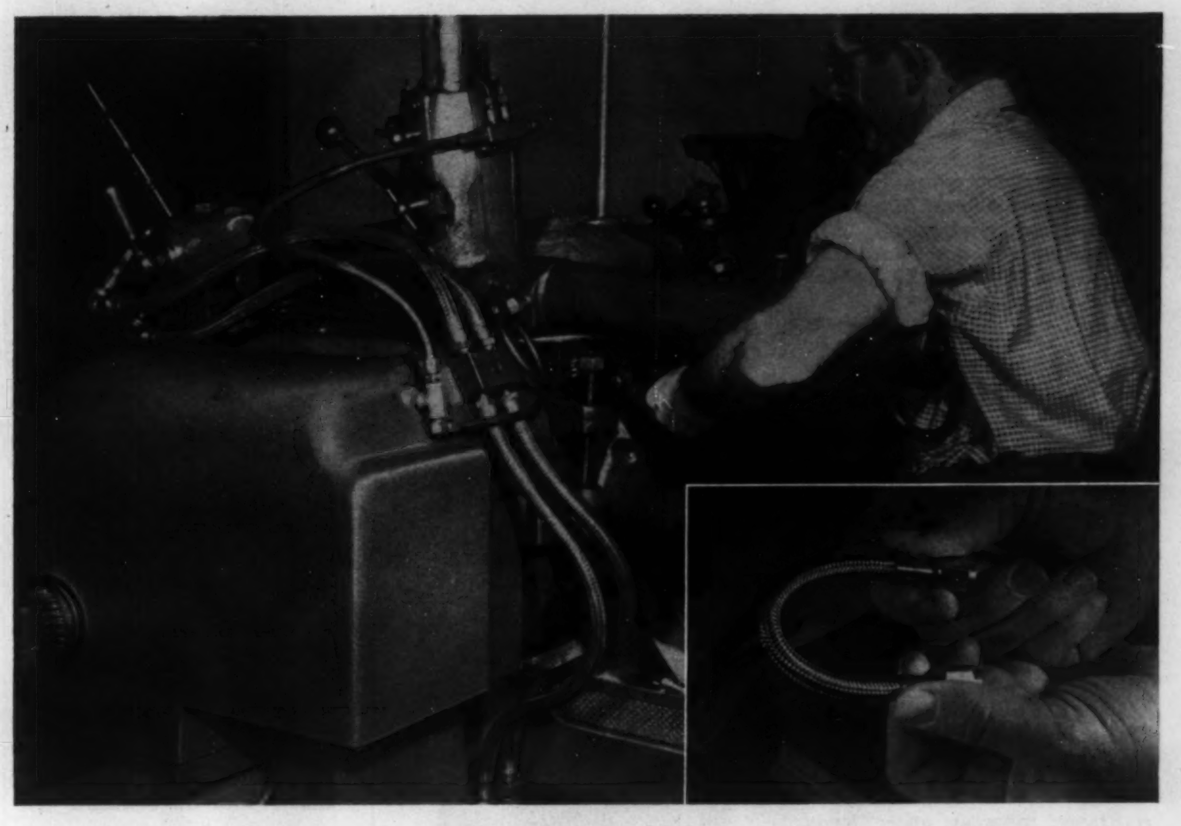


Circle 605 on page 19

Miniature Relays

operate at temperatures from −65 to 125 C

Miniature aircraft-type 4PDT relays, designated Diamond H Series S, have a sealed coil within the hermetically sealed case, and completely inorganic, simplified switch to provide high reliability in dry-circuit applications. They can be stored indefinitely and operate at temperatures from −65 to 125 C without contaminating contacts. Units carry up to 10 amp in power circuits or 20 amp for short-life requirements, permitting inter-



Design high-integrity fluid lines with R/M FLEXIBLE THIN-WALL Teflon* HOSE

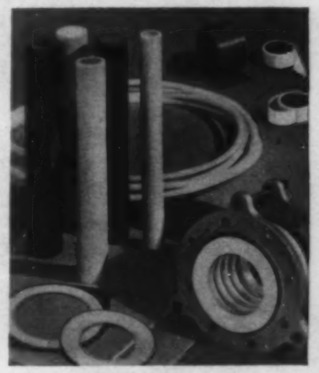
If your design problems include the handling of fluids under conditions of extreme temperature, pressure and corrosion, investigate the possibilities of R/M Flexible Thin-Wall "Teflon" Hose. It retains its toughness and flexibility in temperatures ranging from -100° to 400°F. It withstands pressures (in the wire braid form) to 1500 psi; is completely impervious to all types of acids, caustics and solvents; does not expand, contract or fatigue; and is storable indefinitely without deterioration.

R/M Flexible Thin-Wall "Teflon" Hose can be furnished in both stainless steel wire braid and rubber-covered forms, either coupled or uncoupled.

This hose is another product resulting from R/M's long research in the application of "Teflon." Our laboratories have been developing the vast potentialities of this material for all phases of industry since "Teflon" first came into use. Write today for complete information.

R/M "Teflon" Products: machined parts; rods, sheets, tubes and tape; centerless ground rods held to very close tolerances; stress-relieved molded rods and tubes; gaskets; expansion joints and flexible couplings; bondable "Teflon"; braided metal- and rubber-covered flexible hose; and Raylon (R/M trade name for mechanical grade "Teflon" which has many of the characteristics of virgin "Teflon"). Write for complete data.

*A Du Pont trademark



R/M

RAYBESTOS-MANHATTAN, INC.

PLASTIC PRODUCTS DIVISION, MANHEIM, PA.

FACTORIES: Manheim, Pa.; Bridgeport, Conn.; No. Charleston, S.C.; Passaic, N.J.; Neenah, Wis.; Crawfordsville, Ind.; Peterborough, Ontario, Canada

RAYBESTOS-MANHATTAN, INC., Engineered Plastics • Asbestos Textiles • Mechanical Packings • Industrial Rubber • Sintered Metal Products • Rubber Covered Equipment
Abrasive and Diamond Wheels • Brake Linings • Brake Blocks • Clutch Facings • Laundry Pads and Covers • Industrial Adhesives • Bowling Balls

Circle 460 on page 19

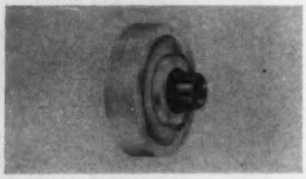
mixed dry and wet circuits. Standard contact ratings include 30 v dc, 115 v ac, 2, 5, $7\frac{1}{2}$ and 10 amp resistive, 2 and 5 amp inductive. Coils are available with resistances of 1 to 50,000 ohms. Nine standard mounting arrangements plus a ceramic plug-in socket are available. **Hart Mfg. Co.,** 110 Bartholomew Ave., Hartford, Conn.

Circle 606 on page 19

Cam Followers

have self-lubricating nylon roller

Rollset cam-follower bearings are a combination of stud and nylon roller, preassembled before shipment. Self-lubricating quality of the nylon roller assures quiet operation, smooth rolling action, and resistance to wear under loads. Stud is zinc or cadmium-plated steel, stainless steel or aluminum. It is left soft for riveting, and is also available threaded, knurled or grooved for special assemblies. **General Bearing Co. Inc.,** 47 Roselle St., Mineola, N. Y.

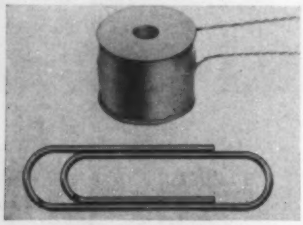


Circle 607 on page 19

Miniature Coils

operate efficiently from -68 to 260 C

All-Teflon insulation in these Hi-Temp coils permits efficient coil operation at temperatures from -68 to 260 C continuous duty. Coils are nongassing throughout the temperature range. Design provides high space factor, permitting the use of more copper in a winding without increasing dimensions. Coils resist most chemicals, do not react with coil metals, and withstand oxygen attack to 300 C. They can be wound in subminiature size, using Teflon wire as small as No. 50 AWG. For extremely high temperature applications, coils are produced with mica insulation. **Tur-Bo Jet Products Co. Inc.,** 424 S. San Gabriel Blvd., San Gabriel, Calif.



Circle 608 on page 19

Plastic Lenses

for industrial and photographic use

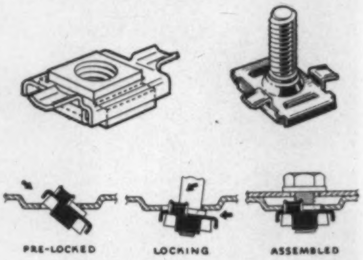
Precision-made plastic lenses are lightweight, unbreakable, easily mounted and flexible for adaptation to varied manufacturing methods. They are easily machinable to any shape and can be optically ground and polished to meet exacting requirements. Spherical shapes and combinations are available in all standard sizes; Fresnel lenses and lenticular screens are also available. Lenses are suitable as condensers, viewers or magnifiers for both photographic and industrial equipment where glass lenses are not practical. **Optics Mfg. Corp.,** Industrial Div., Amber & Willard Sts., Philadelphia 34, Pa.

Circle 609 on page 19

Self-Retaining Fasteners

eliminate welding and staking operations

Speed-Grip nut retainers and bolt retainers, designed primarily for automotive fender application, eliminate welding and staking operations and permit ready installation where assemblies are not easily accessible. Nut retainer (left) is easily drifted into locked, bolt-receiving position with a simple tool. It affords ample float and provides excellent pullout resistance. Bolt retainer operates on the same basic principle, and bolt itself serves as the drifting device. Both fasteners are available for wide range of screw and nut sizes and panel thicknesses. **Tinnerman Products Inc.,** P. O. Box 6688, Cleveland, O.

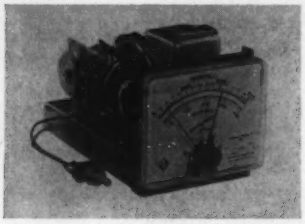


Circle 610 on page 19

Meter-Relay Chassis

in two styles

Two new meter-relay chassis styles, especially designed for use in original equipment, are furnished without side or top panels. Available with all standard control circuits and components, chassis are intended for built-in flush-mounted applications where space saving is important. Contact meter-relays used are $4\frac{1}{2}$-in. wide models, in either clear plastic or black bakelite plastic with glass windows. Chassis are $4\frac{1}{2}$ in. wide and $7\frac{3}{8}$ in. deep. **Assembly Products Inc.,** Wilson Mills Rd., Chesterland, O.



Circle 611 on page 19

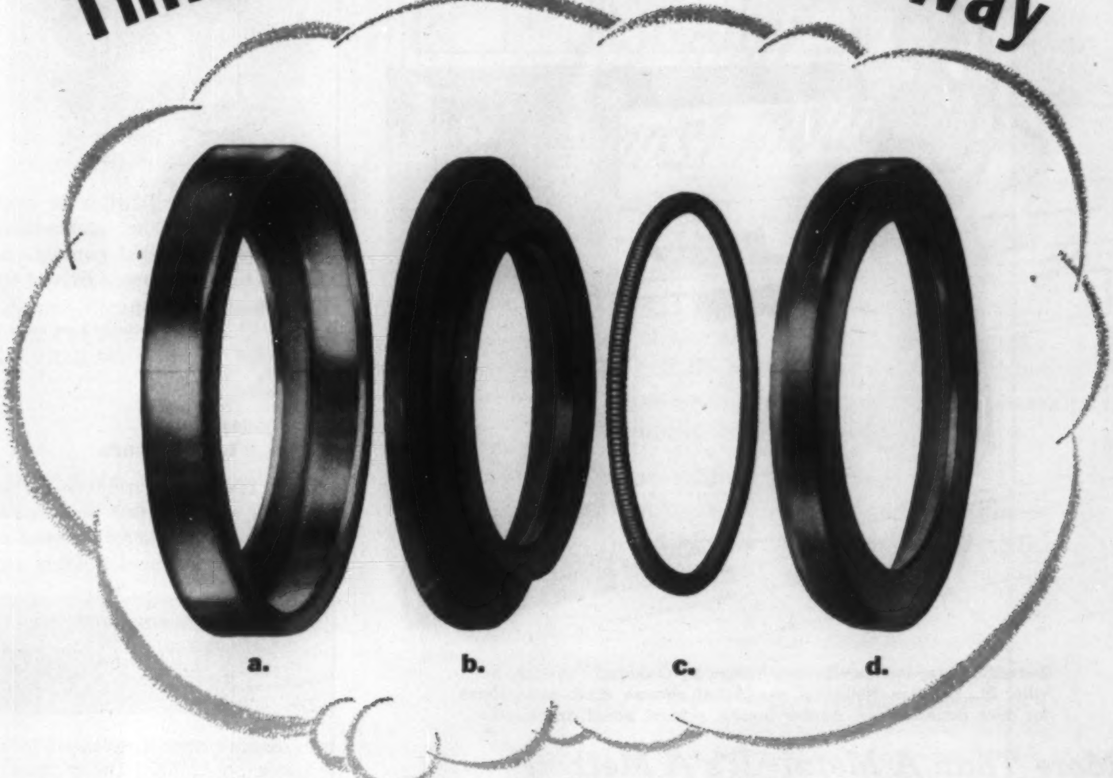
Miniature Chopper

for dry-circuit applications

Syncroverter miniature, nonresonant inverter is available in a low-noise, external-coil model for dry-circuit applications. Chopper offers complete electrostatic shield-

When you design-in seals

Think of Oil Seals This Way



a. Outer Case

Formed to extreme close tolerance of heavy gauge steel with sufficient structural strength to maintain precision dimension.

b. Sealing Lip

Properly prescribed material either compounded or processed for application conditions of temperature and eccentricities. Precisely molded for correct shaft interference, low torque and positive sealing.

c. Tension Spring

Carefully engineered as to metallurgy, heat treatment and coil diameter to provide uniform compressive force on the sealing element.

d. Inner Case

Strengthens, protects; sturdy gauge steel formed to close tolerances.

4227

A good oil seal is a carefully engineered, precision manufactured assembly of carefully engineered, precision manufactured components. Each part must be exactly right *for the given application* or the seal will not function properly.

You avoid dangers of costly retooling, remanufacture or premature replacement when seals are correctly specified during your product's design stage. Each sealing application is different; many designers use National's field engineering service to be sure correct—and latest—oil seals are used.

Why "do it yourself?" Call the National Seal field engineer now. His service involves no obligation.

NATIONAL SEAL
DIVISION, Federal-Mogul-Bower Bearings, Inc.
GENERAL OFFICES: Redwood City, California
PLANTS: Van Wert, Ohio, Redwood City
and Downey, California

36th year

CHICAGO, ILL. . . *Room 462, McCormick Building, HArrison 7-5163*
CLEVELAND, OHIO . *210 Heights Rockefeller Bldg., YEllowstone 2-2720*
DETROIT, MICH. . . . . *13836 Puritan Avenue, VErmont 6-1909*
INDIANAPOLIS, INDIANA . *2802 North Delaware Street, WAlnut 3-1535*
MILWAUKEE, WIS. . . *647 West Virginia Street, BRoadway 1-3234*
NEWARK, N. J. . . . . . *1180 Raymond Blvd., MItchell 2-7586*
DOWNEY (Los Angeles County), CALIF. . . *11634 Patton Road, TOpaz 2-8163*

Circle 461 on page 19

new glamour in the kitchen

with NICKELOID METALS

Pre-Plated Metals Offer Design Freedom, Production Savings!

Beautiful, easy-to-clean built-in range by Oakland Foundry, Belleville, Ill., features Nickeloid pre-plated chrome steel, satin finish, for door panels, oven, burner inserts, control panel and hood.

More Than A Metal—It's A Method

Oakland Foundry, Belleville, Ill., a leading manufacturer of electric ranges, puts it this way: "We were unable to fabricate the alternate material without new tooling. Nickeloid Metals have increased our production, reduced rejects and lowered the costs of our product".

If *you* are caught between increasing manufacturing costs and the constant consumer demands for new and improved products, consider Nickeloid *Pre-Finished* Metals. An extremely versatile design material, they fit right in with standard production techniques, without major retooling — lower manufacturing costs and equipment investment because they require no cleaning, post-plating, polishing. You just fabricate and assemble — *and save!*

Choose from beautiful, durable finishes of chrome, nickel, copper or brass on steel, zinc, copper, brass and aluminum. Sheets, strips, coils.

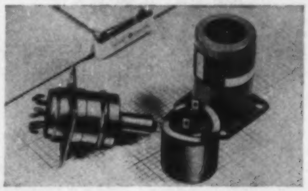
NICKELOID METALS
SINCE 1898
NM

SEE NICKELOID—BOOTH 1307
DESIGN ENGINEERING SHOW
NEW YORK COLISEUM—MAY 20-23

AMERICAN NICKELOID CO.
PERU 8, ILLINOIS

Circle 462 on page 19

ing between contact and coil leads, producing peak-to-peak noise levels less than 100 μv across a 1-megohm impedance. Switch is available with single-pole, double-throw action, with nominal contact ratings up to 10 v, 1 ma. **Bristol Co.,** Waterbury 20, Conn.



Circle 612 on page 19

Air Valve

has delay time from 0 to 30 seconds

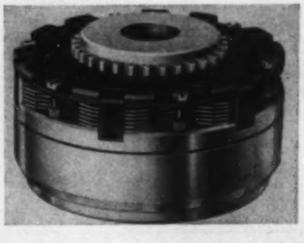
Model BVP-ATD time-delay air valve is suitable for applications requiring a time delay between release of the solenoid holding current and return of solenoid to its original position. Delay time is adjustable between 0 and 30 seconds, with repetition accuracy of ±10 per cent. Valve is available with ¼ through 1-in. ports. **Beckett-Harcum Co.,** 1087 Wayne Rd., Wilmington, O.

Circle 613 on page 19

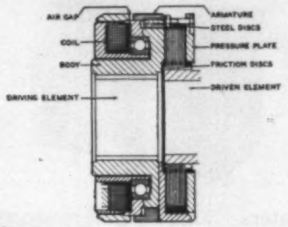
Magnetic Clutch

for wet or dry operation

Design of this magnetic clutch features compact axial and radial dimensions, isolation of magnetic assembly from integral mechanical parts, and precision assembly of all component parts. It is fur-



nished in stationary-field or brush types for either wet or dry operation. Unit has fast operating speed in both engagement and disengagement. It provides complete torque control under all rated conditions. Clutch is available in sizes from 2 to 13 in. **Fawick Corp.,** Airflex Div., 9919 Clinton Rd., Cleveland 11, O.



Circle 614 on page 19

Teflon Hose

for fluid temperatures from −100 to 500 F

Teflon hose with detachable, reusable fittings is available for applications where unusual exposure to wide temperature ranges and injurious chemical action is encountered, such as in steam lines, hot asphalt lines, and other installations where fluid temperatures range from −100 to 500 F. Detachable fitting is leakproof even after aging of hose, can be assembled easily with hand tools, and can be reused many times. Male pipe and JIC swivel fittings are available. **Aeroquip Corp.,** Industrial Sales Dept., Jackson, Mich.

Circle 615 on page 19

Pickup Control Unit

for use with transducer systems

An ac convenience receptacle to permit use of a standard electrical plug at the output is featured on 4951-RAC proximity pickup control unit. Designed for use with sensitive proximity transducer systems, the unit is equipped with fast SPDT mercury-contact relay which provides maximum of 3600

GIVING YOU

...the best and most modern!

Bunting today covers a new area in the engineering and manufacture of bearings and machine parts. To the traditional line of Bunting Cast Bronze Bearings and parts is added up-to-date, soundly established facilities for engineering and manufacturing bearings and parts made of Sintered Powdered Metals.

In an entirely new plant with the very latest equipment, Bunting now attains the position in the Sintered Powdered Metals field which it has long held in the field of Cast Bronze Bearings.

A competent group of Bunting Sales Engineers in the field and a fully staffed Product Engineering Department put at your command, comprehensive data and facts based on wide experience in the designing and use of Cast Bronze and Sintered Powdered Metal Bearings and parts.

Write for catalogs and your copy of the new 24 page Bunting Engineering handbook of Sintered Powdered products and their composition, manufacture and application.

Bunting®

BUSHINGS, BEARINGS, BARS AND SPECIAL PARTS OF CAST BRONZE AND POWDERED METAL

The Bunting Brass and Bronze Company • Toledo 1, Ohio • Branches in Principal Cities

Circle 463 on page 19

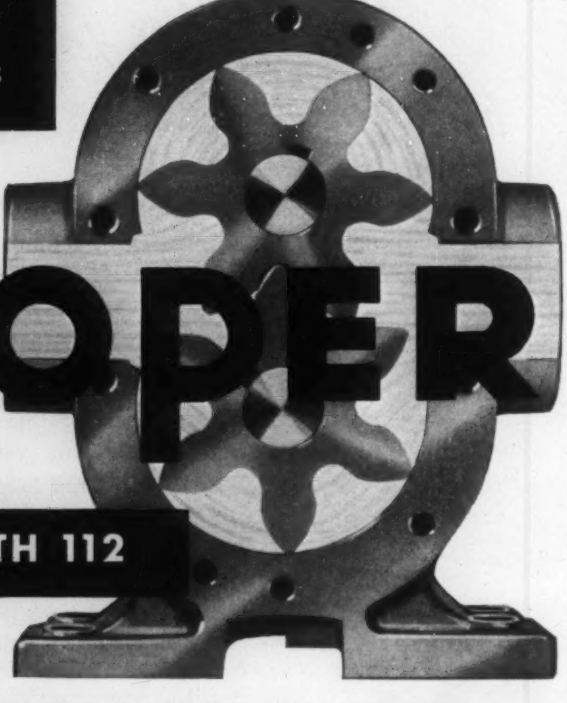
1957
Design
Engineering
Show

New York
Coliseum
May 20 to 23

At the show...

ROPER

BOOTH 112



FIND OUT WHAT THESE PUMPING GEARS CAN DO FOR YOU!

STANDARD PUMPS — A large selection for hydraulic or processing equipment . . . pressure lubrication . . . fuel transfer . . . or you name it! Including all categories, you choose pumps in capacities from 5 to 300 GPM — pressures to 1000 PSI.

SPECIAL PUMPS — Many customers have effected great savings by having Roper modify a standard pump into a Roper "special" pump. A thorough analysis of your specifications will tell whether this is the practical approach to your requirements.

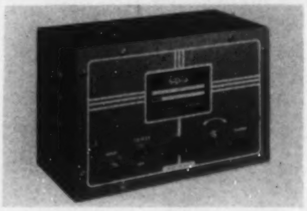
CUSTOM PUMPS — In these units, Roper employs the basic, tested principle of two equal size gears running in a precision fitted case. When the job is so complex only a custom pump will do, then depend on Roper to help you achieve the results you want.

NOT GOING? SEND FOR CATALOG 957

GEO. D. ROPER CORPORATION
245 Blackhawk Park Ave.
Rockford, Illinois

ROPER
Rotary Pumps

operations per minute. The device is used to operate and control circuits, electrical machinery, batch



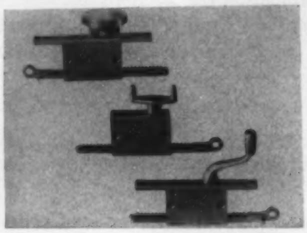
counters and electromechanical counters, and in similar industrial applications. **Electro Products Laboratories,** 4500 Ravenswood Ave., Chicago 40, Ill.

Circle 616 on page 19

Mechanical Adjustor

converts rotary to linear motion

This mechanical adjustor, unusually easy to operate, has a capacity in excess of 250 lb. It transfers rotary motion into vertical or horizontal motion and travels 3 in. in 20 revolutions. Unit is available with various handles or knobs to meet individual requirements, and with or without face-mounting flange to permit all types of installations. **Parlyn Products,** 556 S. Monterey Pass Rd., Monterey Park, Calif.



Circle 617 on page 19

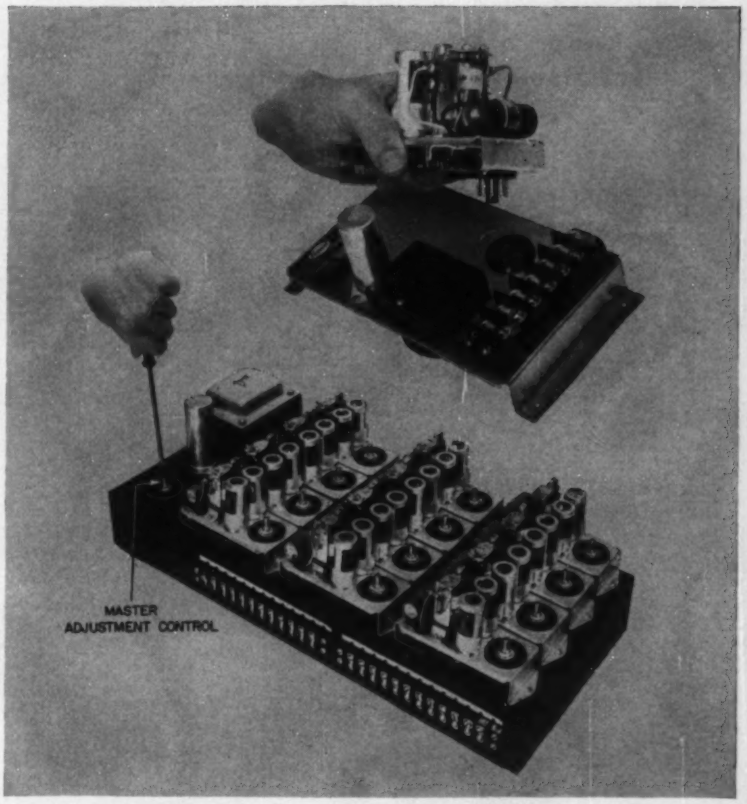
Pressure Transducer

is unaffected by temperature changes

Barometric pressure transducer requires no electric equipment, and has transfer functions which can be made to match any design requirement. Unit is completely passive and has very low ac power consumption. Comparatively unaffected by temperature changes, it has a range from sea level to 40,000 ft. Output ratio is propor-

Circle 464 on page 19

THERMISTOR DEVICES GIVE 1 TO 100 POINT TEMPERATURE CONTROL



FENWAL'S SERIES 53000 UNIT THERMISTOR CONTROLLER — Serves a single temperature control point, but can be combined easily with others, like building blocks, to make up a central system serving up to 100 control points with a single master control if desired. You should know about this. Write Fenwal for details.

Fenwal Units' Accuracy is .25% of Scale

ASHLAND, MASS. — Fenwal engineers here have designed a new Controller using a thermistor and a simple electronic circuit, and the result is a temperature-control system versatile and accurate to within .25% of scale.

The thermistor principle is this: the electrical resistance of the sensing element decreases as its temperature rises. The resistance changes for very small temperature changes are large, making extremely accurate temperature measurement possible.

In the Fenwal system, the thermistor, with its amazing sensitivity and fast responses, feeds an electronic bridge circuit that uses standard tubes. The small thermistor probe, available in several styles, is mounted at the point you wish controlled.

You can mount the compact Unit Controller up to 200 feet away from the control point without losing sensitivity. You can connect it with ordinary lamp cord.

Tailor-Made Designs

But possibly the biggest news in the design is the way the Unit Controllers can be assembled with a common power supply, like building blocks, to provide you with a central system serving up to 100 control points.

The units are, of course, ideal for use singly as well — each unit serving a single control point, each unit with its own power supply.

The many possible combinations of units are known collectively as the Fenwal Series 53000. There are four standard temperature ranges for you to choose from: −100°F to 50°F; 0°F to 150°F; 100°F to 300°F; and 200°F to 600°F. Special ranges can, of course, be supplied in most cases.

Each Controller includes a potentiometer for temperature adjustment, which you can locate remotely, if you wish. For multiple units, you can have a single master control. This control will let you adjust a complete system, while permitting compensating adjustment for each individual Controller, too.

These Thermistor Controllers are already serving hundreds of companies in many industries. Why not yours? You'll be surprised how inexpensive good control can be.

Designers and process engineers — you will want to have details on this new advance in precision temperature control at your fingertips. Write for information on the Series 53000 Unit Thermistor Controllers to **Fenwal Incorporated, 195 Pleasant Street, Ashland, Mass.**

Fenwal

CONTROLS TEMPERATURE
. . . PRECISELY

Circle 465 on page 19

Special

BALLS

. . in experimental and production quantities—

For

- HIGH TEMPERATURES
- CORROSION RESISTANCE
- NON-MAGNETIC PROPERTIES

. . other special requirements

ALL SIZES, standard and special, from 1/64" to 12" or more, depending on material.

ALL MATERIALS, including special ferrous and non-ferrous alloys, plastics, ceramics, carbides, synthetic sapphire.

MODIFIED BALLS, with slots, undercuts, tapped holes, etc.

We also provide
PRODUCTION SERVICE
on spherical and
toroidal surfaces.

Write for quotation and descriptive literature.

INDUSTRIAL TECTONICS, Inc.
3670 Jackson Rd., Ann Arbor, Michigan
18302 Santa Fe Avenue
Compton, California

ITI
PRECISION BALLS AND
SPECIAL ANTI-FRICTION BEARINGS

Circle 466 on page 19

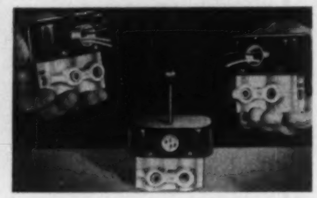
tional to barometric pressure within close limits. Input and output impedance levels can be designed to operate with any gyro or signal generator. **Darco Industries Inc.,** Gyro-Dynamics Div., 2151 E. Rosecrans Ave., El Segundo, Calif.

Circle 618 on page 19

Control Valves

operate double-action cylinders

Three Quick-Dump control valves are four-way, five-port models which provide smooth operation of double-action cylinders. Two of the valves are electrically operated; the third is equipped with hand lever. Electric valves employ electromagnetic armatures. Full ¼-in. internal ports provide 80 cfm of air at 100 psi line pressure. **General Gas Light Co.,** Humphrey Products Div., 202 N. Park St., Kalamazoo, Mich.

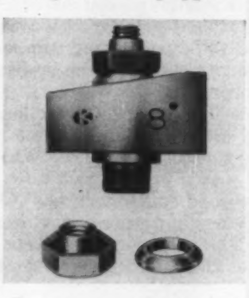


Circle 619 on page 19

Hex Nut

for temperatures to 550 F

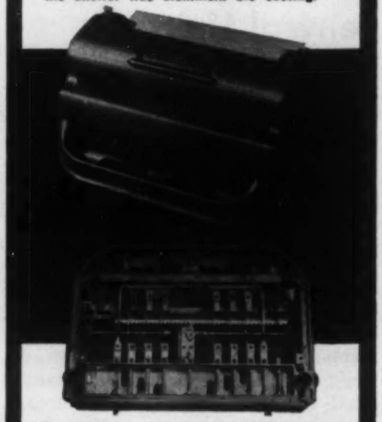
Kaylock H19000 self-aligning and self-locking hex nut provides for misalignment of up to 8 deg in any direction between bolt holes and mounting surfaces. It eliminates need for spotfacing or use of tapered shims in applications such as tapered spar caps, tapered skins, forgings and castings with draft angles. Equipped with



PB = ?
PB = HB

Problem: What would be the finest type of casting for our Perkins Brailler which would be lightweight, rugged and low in cost . . . and where can it best be done?
Solution: Versatile Aluminum Die Casting . . . by Hampden Brass & Aluminum Co.

When the Perkins Institute for the Blind was faced with the problem of the best possible casting method to use for their Braille writer, they called on Hampden's 50 years experience and know-how . . . and the answer was aluminum die casting.



For the first time, the world over, a completely portable Braille writer was produced . . . cast in eleven die castings! Remarkably lightweight (Braille writer weighs only 9 lbs.) yet it has an embossing pressure of 40 lbs! The intricacies possible in aluminum die casting permit the castings to be held together by screws and nuts, the nuts being located in cored pockets. The flexibility of this' arrangement allows the castings to be easily handled, enamel-baked . . . and assembled without any drilling or fitting.

Remember . . . whether your casting problems are big, tiny, intricate, or special . . . Hampden is ready to effectively solve them with premium quality castings of aluminum or other non-ferrous metals . . . utilizing the sand, permanent mold or die casting method. Our more than 50 years' know-how is your assurance of the best casting techniques to help reduce costs and improve performance.

Why not contact Hampden Brass & Aluminum Co. on your next casting problem . . . and avail yourself of our engineering counsel?

Send for brochure, "Behind the Scenes" . . . complete digest of Hampden's experience, equipment and facilities.

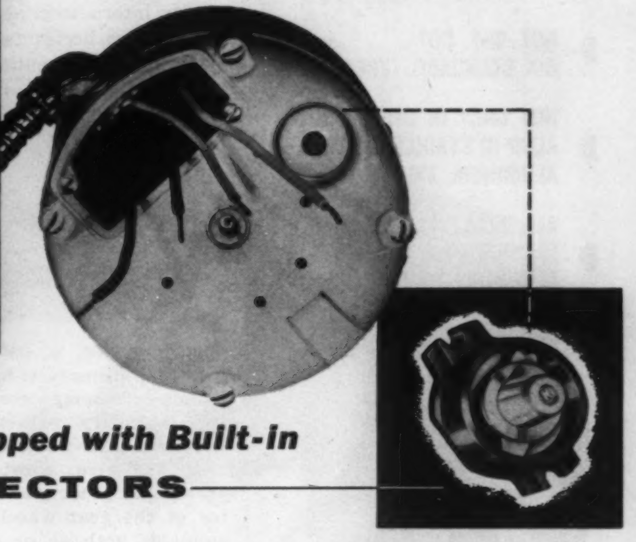
HB

HAMPDEN BRASS
AND ALUMINUM CO.
Established 1903
262 Liberty St.•Springfield, Mass.
Producers of Sand, Permanent Mold, Die & Fiberglas Castings

Circle 467 on page 19

IN-SINK-ERATOR
FOOD WASTE DISPOSER
IN·SINK·ERATOR
FOOD WASTE DISPOSER

There are no motor burnouts in famous IN-SINK-ERATOR garbage disposers



Because . . . they are equipped with Built-in

KLIXON PROTECTORS

In describing its newest food disposer, the In-Sink-Erator Manufacturing Company points out that this Model 77 special offers everything the consumer wants for convenient, service-free operation.

Part of the reason for this service-free operation is In-Sink-Erator's continuing use of Klixon Protectors in its motors. Here's what E. E. Wieczorek, V.P. in Charge of Manufacturing, says about Klixon Protectors:

"We have been incorporating Klixon Inherent Protectors in our In-Sink-Erator food disposer for many years and, from such continued use, we've been able to eliminate motor burnouts and substantially reduce field service."

In-Sink-Erator learned long ago the value of specifying and using Klixon Protectors as a built-in part of its products. You, too, can keep motors in your equipment or products working dependably by specifying and using Klixon Protectors in your motors. They will reduce maintenance costs, service calls, and repairs and replacements. The additional cost is low . . . the benefits exceptionally worthwhile.

Now There's Something New

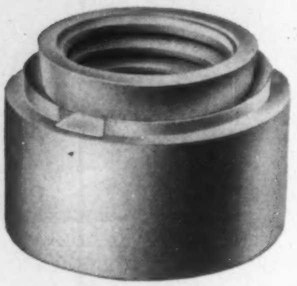
In addition to the famous Klixon Protector for single-phase motors, you can now get full protection engineered into 3-phase motors with a single, built-in Klixon Protector. For details write for Bulletin MOPR1.

METALS & CONTROLS CORPORATION
Spencer Thermostat Division
3205 Forest Street, Attleboro, Mass.
KLIXON

did you know?

PEM Self-Clinching Fasteners are now available in—

- NOT ONE, BUT SIX STANDARD TYPES
- NOT ONLY IN STEEL—BUT ALSO IN STAINLESS STEEL, ALUMINUM, MONEL
- ALL UTILIZING THE SAME FAMOUS PEM SELF-CLINCHING PRINCIPLE



find out why...

Many leading manufacturers have standardized on PEM Self-Clinching Fasteners, for load carrying threads in sheet metal "too thin to thread". The fasteners that are "clinched by a squeeze with the greatest of ease"—to save assembly time and labor.

Write for literature and samples for test. Penn Engineering & Manufacturing Corp., Doylestown, Pa.

PEM

Circle 469 on page 19

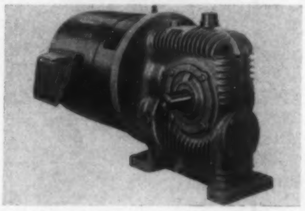
spherical seat and matching lightweight washer, the nut is designed for use in temperatures to 550 F. It meets military specification requirements for self-locking nuts, and is available in sizes 10-32 and ¼-28. **Kaynar Co.,** Kaylock Div., Box 2001, Terminal Annex, Los Angeles 54, Calif.

Circle 620 on page 19

Gearmotors

carry heavy loads and absorb shock

Right-angle gearmotors with heavy load-carrying and shock-absorbing qualities are available with 1 to 10 hp for continuous duty and 1 to 30 hp for intermittent duty. Design incorporates horizontal or vertical mountings, conventional double shaft, hollow shaft, one-piece reducer housing, a pair of helical gears for primary reduction, and a double-enveloping worm gear set for secondary reduction. Worm shaft and gear-wheel teeth are concave to give constant double-throated contact over a 45-deg sector of the gear wheel. Units are available with ac or dc motor of any speed or duty rating, and any standard enclosure. **Reliance Electric & Engineering Co.,** 24701 Euclid Ave., Cleveland 17, O.



Circle 621 on page 19

Light Source

has projection distance to 8 ft

High-efficiency light source for use in photoelectric applications is small in size, has long bulb life, and provides projection distances up to 8 ft. Simple lens system is used in conjunction with a confined 4-cp filament lamp. Removable lens-mounting ring allows light slit masks to be incorporated. Self-contained series-limiting resistor provides lamp life expectan-

(*Continued on Page* 138)

asg

UNIVERSAL JOINTS

available in 13 sizes with bored or solid hubs

You can get ASG Universal Joints directly from stock in 13 sizes with bored or solid hubs ranging in diameter from .375" to 4.000". Special bores, bores with keyways or setscrews are available upon special order.

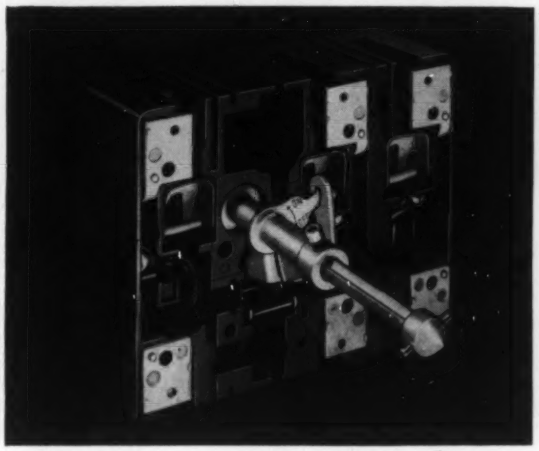
ASG Universal Joints are ruggedly constructed of heat treated alloy steel. Matching or mating parts are precision ground to permit easy interchangeability of components. Joints of ⅞" length and longer have snap ball oilers. Smaller Joints have oil holes. Oil enters at center of rotation to assure thorough lubrication of moving parts.

Send today for Bulletin No. 257 describing the full line of A.S.G. Universal Joints available from your nearest distributor.

AMERICAN STOCK GEAR DIVISION
PERFECTION GEAR COMPANY
HARVEY, ILL., U.S.A.

Circle 470 on page 19

• ANOTHER ADVANCED DESIGN FROM WESTINGHOUSE • ANOTHER ADVANCED DESIGN FROM WESTINGHOUSE •



NEW

Westinghouse VISI-FLEX De-ion Switch fits any panel

ADVANCED DESIGN FROM WESTINGHOUSE • ANOTHER ADVANCED DESIGN FROM WESTINGHOUSE • ANOTHER ADVANCED DESIGN FROM WESTINGHOUSE

• ANOTHER ADVANCED DESIGN FROM WESTINGHOUSE ANOTHER ADVANCED DESIGN FROM WESTINGHOUSE •

This compact new type of panel switch features . . .

- Visible contacts
- Fused or unfused operation
- Choice of Vari-depth or toggle handle
- Standard cover drilling
- Fast mounting
- Low cost

Quick-make, quick-break action plus De-ion arc-quenching grids assures positive switching, long operating life. Ready visibility of the blades means extra safety.

The Vari-depth operator, featuring a threaded telescoping shaft, makes it easy to fit panels of various depths . . . without mounting stilts. It also simplifies cover drilling.

Fuse kits permit mounting several sizes of fuse clips on the switch. As a fused switch, Visi-Flex saves space and the cost of separate fuse blocks.

For use as a disconnect switch, a safety shield without fuse clips is available. You just order the basic switch and the required kit . . . all hardware is included.

Low in cost, flexible, simple to install, Visi-Flex requires a mininum of space. Visi-Flex switches come in 30- and 60-ampere ratings. 100- to 200-ampere models available later.

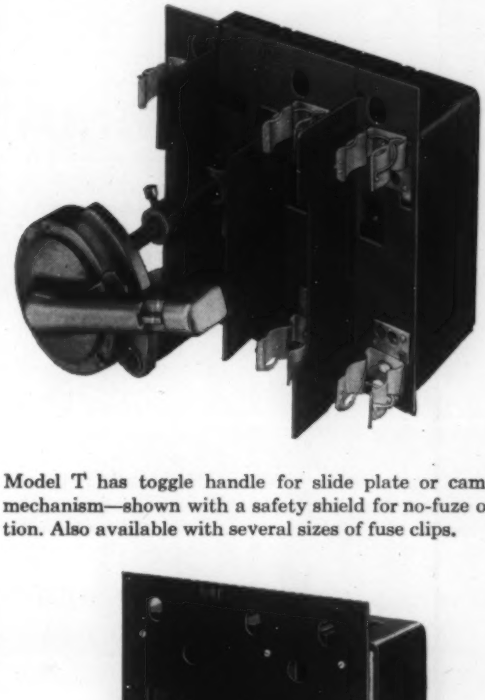
For additional information write to Westinghouse Electric Corporation, Box 868, Pittsburgh 30, Pa., for Booklet SM-5457.

J-30276

YOU CAN BE **SURE**...IF IT'S

Westinghouse

Model A has adjustable Vari-depth handle mechanism—shown with fuse kit assembled. Also available with safety shield for no-fuze operation.



Model T has toggle handle for slide plate or cam-type mechanism—shown with a safety shield for no-fuze operation. Also available with several sizes of fuse clips.

• ANOTHER ADVANCED DESIGN FROM WESTINGHOUSE • ANOTHER ADVANCED DESIGN FROM WESTINGHOUSE •

Circle 514 on page 19

the editors' corner

BOOTH NO. 232

Come in and see us at the

DESIGN ENGINEERING SHOW!

Perhaps you have an article idea you want to talk about?

Or is there a particular topic that has already appeared in MACHINE DESIGN that you would like to discuss?

We'll all be on hand at the Design Engineering Show at the New York Coliseum May 20 through May 23, 1957.

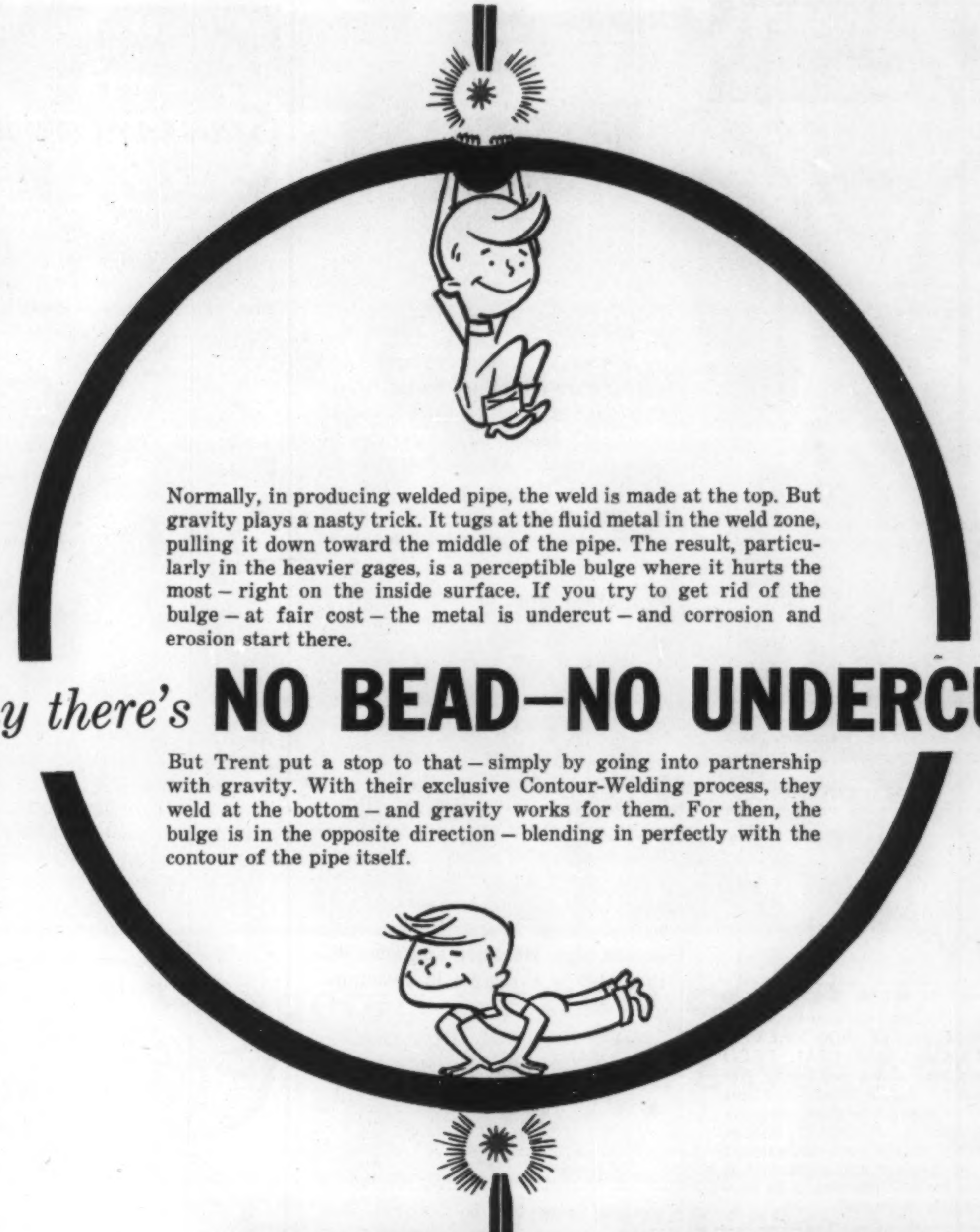
Come in anytime during show hours. We're located in Booth No. 232—right opposite the entrance on the first floor.

The Editors

MACHINE DESIGN

A PENTON PUBLICATION • CLEVELAND 13, OHIO

NBP BPA SBME



Normally, in producing welded pipe, the weld is made at the top. But gravity plays a nasty trick. It tugs at the fluid metal in the weld zone, pulling it down toward the middle of the pipe. The result, particularly in the heavier gages, is a perceptible bulge where it hurts the most – right on the inside surface. If you try to get rid of the bulge – at fair cost – the metal is undercut – and corrosion and erosion start there.

why there's **NO BEAD–NO UNDERCUT**

But Trent put a stop to that – simply by going into partnership with gravity. With their exclusive Contour-Welding process, they weld at the bottom – and gravity works for them. For then, the bulge is in the opposite direction – blending in perfectly with the contour of the pipe itself.

. . . with new **CONTOUR TRENTWELD**

New Contour-Trentweld stainless pipe and tubing is so smooth, both inside and out, that you can't even feel the weld. It's stronger, more uniform, with no place for corrosion or erosion to get a toe-hold. And it's available in any size or gage . . . in all stainless, high-alloy, Hastelloy and titanium grades that can be welded.

CONTOUR TRENTWELD

Stainless and High Alloy Welded Tubing

TRENT TUBE COMPANY, GENERAL SALES OFFICES, EAST TROY, WISCONSIN (Subsidiary of Crucible Steel Company of America)

Circle 471 on page 19

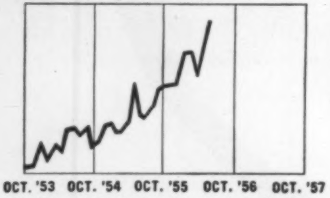
Does **VOLKSWAGEN** bother *Cadillac?*

We don't make CADILLAC air cylinders and we don't pretend that we do . . .

We do claim that we make very good cylinders at very good prices:

BORE	BASIC PRICE	ADD PER " OF STROKE
1⅛"	$15.50	$.35
1½"	$20.50	$.50
2"	$25.50	$.55
2½"	$29.50	$.65
3"	$32.50	$.95
4"	$47.50	$1.20

We furthermore claim that we work hard to ship from stock and our sales chart tells us that we are being successful on all accounts –
PRICE, QUALITY, SERVICE.



Besides cylinders, we also make the ALLENAIR line of AIR VALVES, AIR CLAMPS and DIAL FEED TABLES and if we could tell you right here all there is to tell you about what we offer and how those products can increase your PRODUCTION at MINIMUM COST we wouldn't need the $1.25 24-page catalogue that is available for free this month to anyone seriously interested.

THE A. K. ALLEN CO. MD-57
57 Meserole Ave., Brooklyn 22, N. Y.
Name..
Company..
Address...
City.......................**Zone**......**State**...........

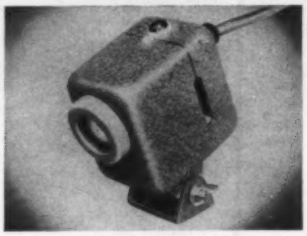
P.S.–*The cylinder pictured is a Factory Reject. The only rods available are straight ones and made out of #416 Stainless Steel ground and polished stock and repolished after machining. The bearing is nylon.*

The answer to the question on top of this page is: *Not one bit. There is a market for both!*

ALLENAIR **THE A. K. ALLEN CO.**
57 Meserole Ave., B'klyn 22, N. Y.

Circle 472 on page 19

(*Continued from Page* 136)



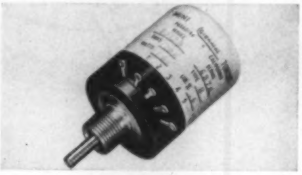
cy of 1500 hr. Lamp and inside lens surface are easily accessible. Model 6300 unit is designed for 6.3-v ac or dc input; Model 6275 operates on 12-v ac or dc. **Autron Engineering Inc.,** 1254 W. Sixth St., Los Angeles 17, Calif.

Circle 622 on page 19

Potentiometer

withstands high vibration and acceleration

Low torque (0.003 oz-in.) of Model 85151 Minitorque potentiometer makes it suitable for applications where no appreciable loading can be tolerated. The unit, which has a diameter of 1 in. and weight of 0.6 oz, features a heavy-duty, 0.125-in. stainless - steel shaft mounted on miniature shielded ball bearings. Potentiometer withstands high vibration and acceleration and is available in resistance ranges from 100 to 100,000 ohm. Noble metal alloy windings and brushes give positive electrical contact with low brush pressure, maximum protection against atmospheric corrosion, and minimum operating noise. **G. M. Giannini & Co. Inc.,** 918 E. Green St., Pasadena 1, Calif.



Circle 623 on page 19

Truck Transmission

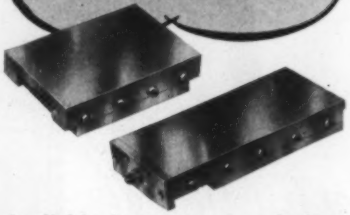
has ten speeds

StepMatic semiautomatic, heavy-duty truck transmission minimizes shift lever and clutch pedal manipulation and reduces need for

SAVE DESIGNING AND MANUFACTURING TIME
with these
Standard COMPONENTS FOR *Special* MACHINES

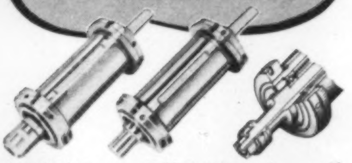
COMPLETE your *special* production equipment faster with *standard* components from this extensive line. Highest precision and quality—many sizes available from stock. *Get complete details!*

STANDARD
Slide
ASSEMBLIES



Available in 52 types and sizes. *Basic Type* includes male and female members, gib and gib screws. *Assembled Type* also has return springs, stop screw, Neoprene shield and mounting holes. Sliding surfaces furnished either *Milled* or *Hand Scraped.* Widths from 2″ to 6″—lengths from 3″ to 16″.

STANDARD
Spindle
ASSEMBLIES



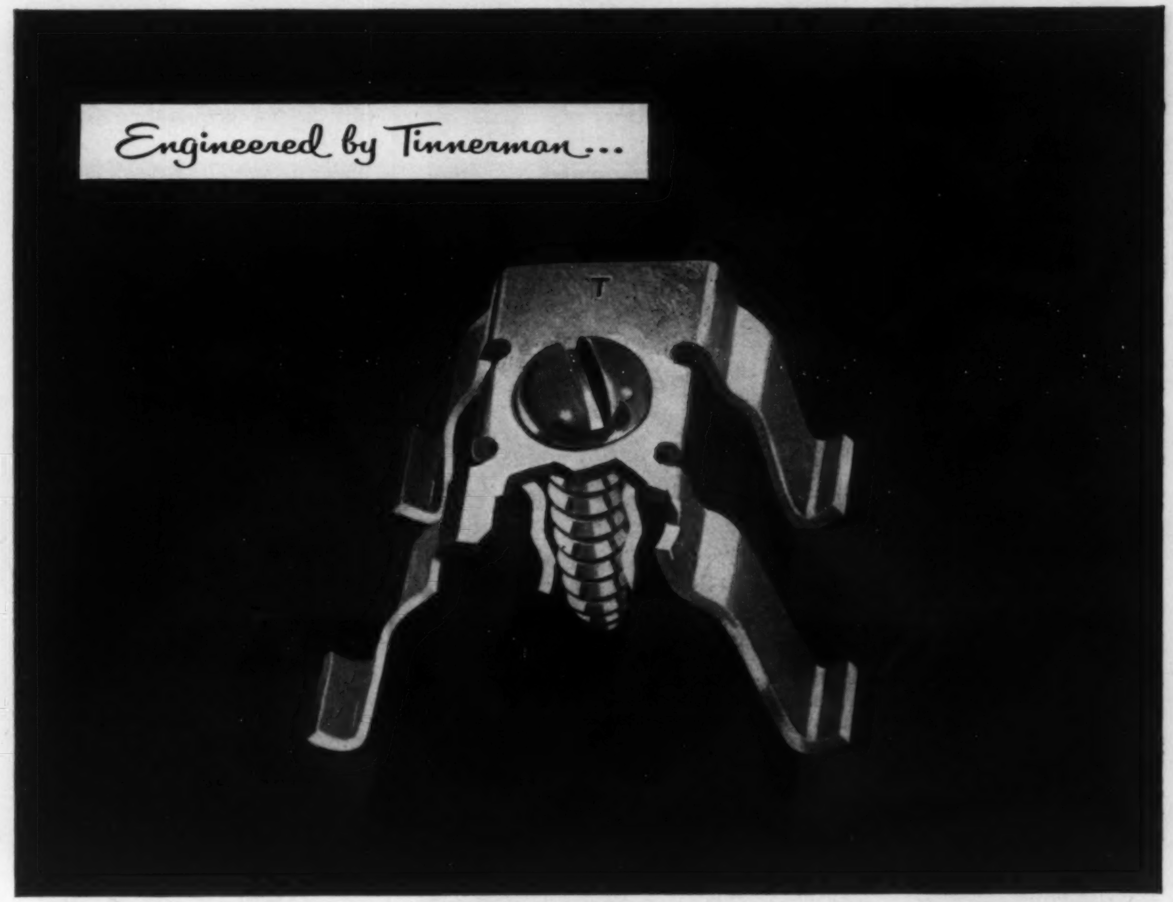
Available in *Collet Type* for ⅛″, 3⁄16″ and ¼″ max. capacity collets; *Morse Taper Type* for No. 0 and No. 1 Morse taper shanks; and *Arbor Type* for shankless cutters with 0.375″ and 0.500″ center hole. *Standard Duty* has single row ball bearings at both ends; *Heavy Duty* has double row bearings at front.

WRITE now for FREE catalog!

RUSSELL T. GILMAN, Inc.

619 Beech St.
Grafton, Wisconsin

Circle 473 on page 19



6-fingered **SPEED CLIP**®
holds glass panels tight, saves 46%!

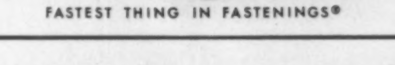
This special SPEED CLIP fastens glass panels to aluminum extrusions with a grip that prevents slippage. Heat stays in, rain stays out of greenhouses and similar glass structures. Working closely with engineers of the Metropolitan Greenhouse Mfg. Corp., Brooklyn, Tinnerman developed this unique fastener that saves almost one-half the cost of former less effective assembly methods!

Installation is fast and simple. Two overlapping glass panels are positioned against the extrusion. A screw driven into the spring-steel SPEED CLIP spreads the two center fingers outward to grip the inner walls of the extrusion. No secondary fastening devices required—SPEED CLIPS hold tight, yet are easily removed to permit replacement of glass.

This is another example of a fastener engineered by Tinnerman to satisfy special, complicated fastening problems. A Fastening Analysis of your products may produce a similar cost-cutting solution. See your Tinnerman representative soon.

TINNERMAN PRODUCTS, INC.
BOX 6688 • DEPT. 12 • CLEVELAND 1, OHIO

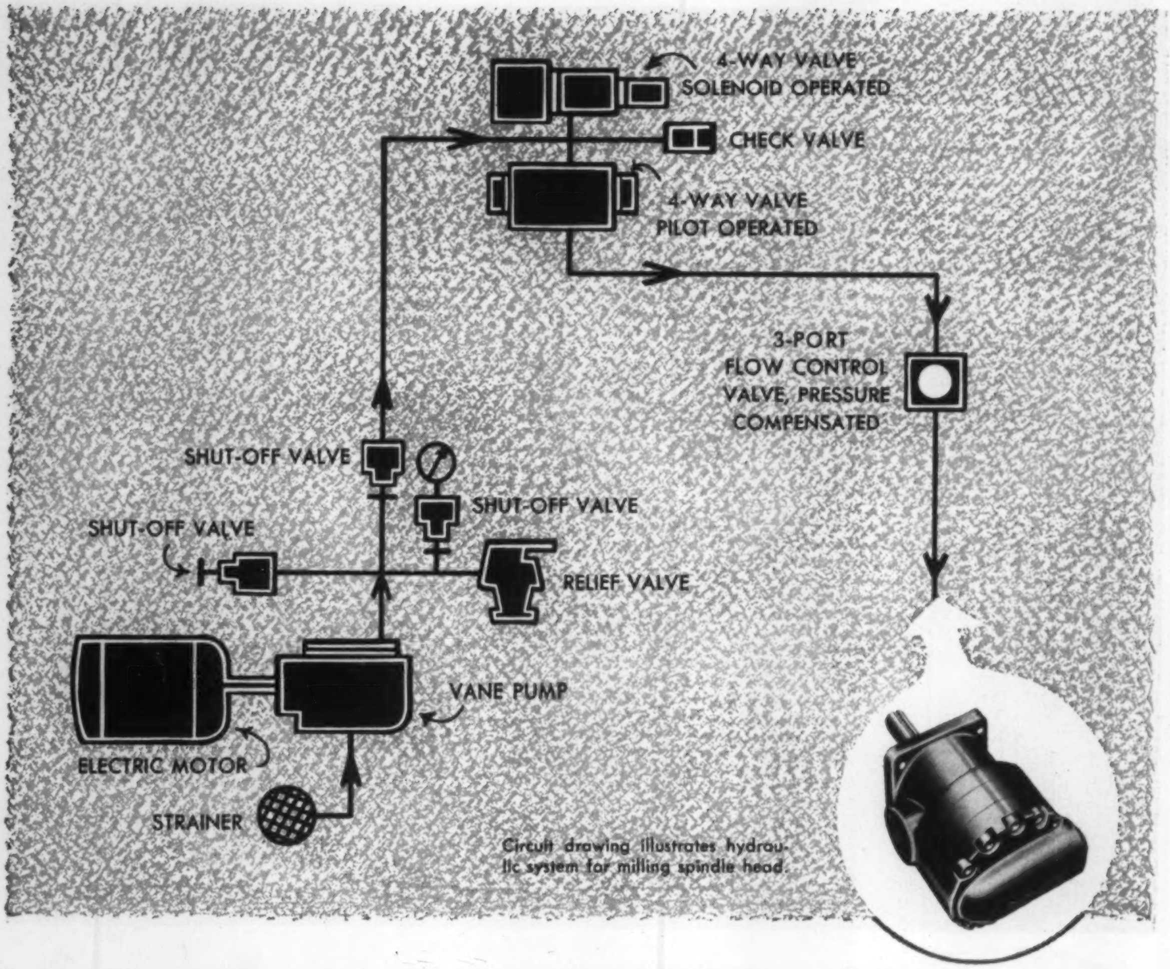
TINNERMAN
Speed Nuts®



FASTEST THING IN FASTENINGS®

Canada: Dominion Fasteners, Limited, Hamilton, Ontario. Great Britain: Simmonds Aerocessories, Limited, Treforest, Wales. France: Simmonds, S. A., 3 rue Salomon de Rothschild, Suresnes (Seine). Germany: Hans Sickinger GmbH "MECANO", Lemgo-I-Lippe.

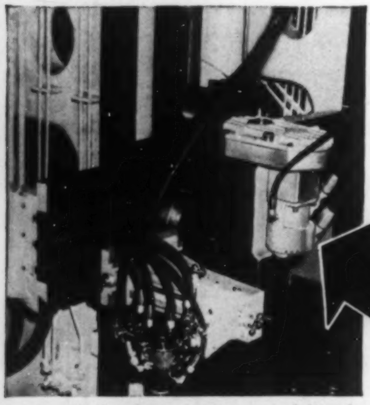
Circle 474 on page 19


4-WAY VALVE
SOLENOID OPERATED
CHECK VALVE
4-WAY VALVE
PILOT OPERATED
3-PORT
FLOW CONTROL
VALVE, PRESSURE
COMPENSATED
SHUT-OFF VALVE
SHUT-OFF VALVE
SHUT-OFF VALVE
RELIEF VALVE
VANE PUMP
ELECTRIC MOTOR
STRAINER

Circuit drawing illustrates hydraulic system for milling spindle head.

Developing a compact, efficient spindle head

...another application for Denison hydraulic power



Denison hydraulic motor is mounted directly to gear case of spindle and powers driver gear of the gear train.

THE PROBLEM: to develop a compact, efficient milling spindle head with infinitely variable spindle speed and instantaneous speed selection.

For True-Trace Sales Corporation of El Monte, California, the solution involved the use of hydraulic power... and Denison hydraulic equipment.

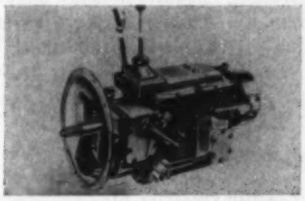
The result was spindle with a 15 hp rating and speeds up to 3000 RPM. To drive the spindle, True-Trace selected a Denison TMC-3 fluid motor. Variable speed control is achieved with a Denison 3-port flow control valve. The control's nine separate ranges permit exact speed selection by the operator.

Let a Denison hydraulic specialist help you with your design problems. Write Denison Engineering Division, American Brake Shoe Co., 1240 Dublin Road, Columbus 16, Ohio.

HYDRAULIC PRESSES • PUMPS • MOTORS • CONTROLS

DENISON HydrOILics

skilled gear shifting. It is an integrated combination of a five-speed synchronized transmission and auxiliary gear train. Auxiliary unit is composed of a direct and an underdrive gear set which are semiautomatically engaged. Underdrive gear ratio splits the



geared steps of the transmission, resulting in ten closely spaced gear ratios. Model 303X is rated for engine torque output of 300 lb-ft, and Model 400X for 425 lb-ft torque. **Clark Equipment Co.**, Transmission Div., Falahee Rd., Jackson, Mich.

Circle 624 on page 19

Instrument Ball Bearings

in thin-section size

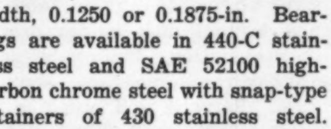
No. 814 thin-section ball bearings have been added to a line of instrument ball bearings. Bore is 0.2500-in., OD is 0.5000-in. and width, 0.1250 or 0.1875-in. Bearings are available in 440-C stainless steel and SAE 52100 high-carbon chrome steel with snap-type retainers of 430 stainless steel. They have either single or double shield, with or without flange. Retainers are precision stamped with channel-type rolled sections and coined ball pockets. **Miniature Precision Bearings Inc.**, Precision Park, Keene, N. H.

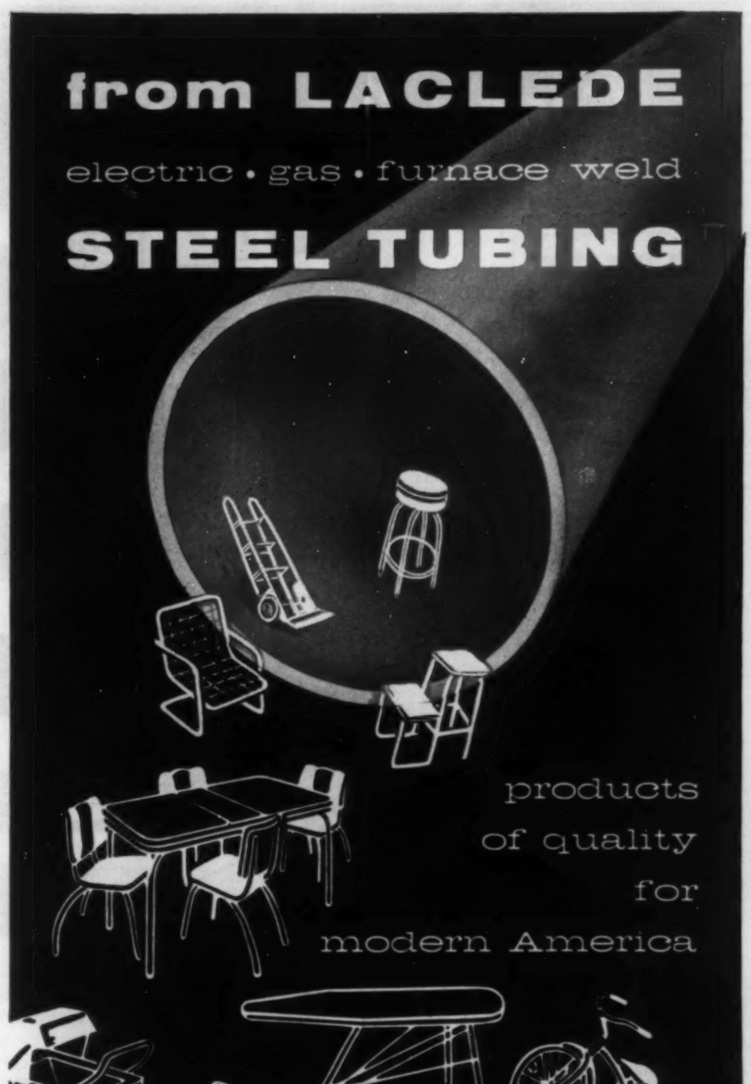
Circle 625 on page 19

Pancake Pickup

for proximity transducers

Model 4925-AN pancake pickup for use with proximity transducer systems senses metallic masses at a distance. It provides extra sensitivity through the use of large coil





from LACLEDE

electric • gas • furnace weld

STEEL TUBING

products
of quality
for
modern America

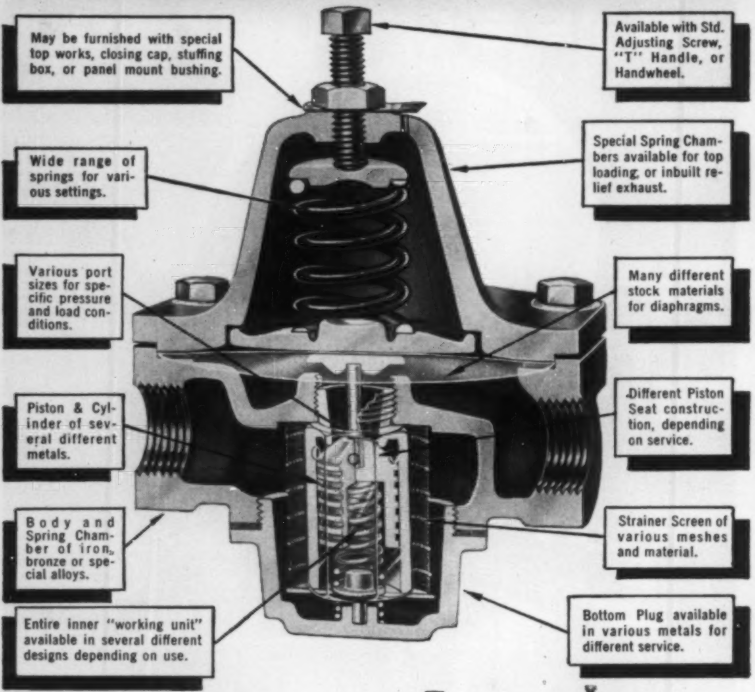
LACLEDE

LACLEDE STEEL COMPANY

Saint Louis, Missouri

Circle 476 on page 19

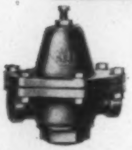
how **Cash-Acme** provides the **Correct Answer** to 1,017 reducing valve cost problems


May be furnished with special top works, closing cap, stuffing box, or panel mount bushing.
Available with Std. Adjusting Screw, "T" Handle, or Handwheel.
Wide range of springs for various settings.
Special Spring Chambers available for top loading or inbuilt relief exhaust.
Various port sizes for specific pressure and load conditions.
Many different stock materials for diaphragms.
Piston & Cylinder of several different metals.
Different Piston Seat construction, depending on service.
Body and Spring Chamber of iron, bronze or special alloys.
Strainer Screen of various meshes and material.
Entire inner "working unit" available in several different designs depending on use.
Bottom Plug available in various metals for different service.

Here's How: With over 1,017 models and modifications of Cash-Acme's *standard* Type B Pressure Reducing Valve available and already in high production, the *right* regulator can usually be quickly selected from stock to do the job you require. This offers important cost savings as delays, special tooling and custom design and engineering are eliminated.

Do as other cost conscious engineers and purchasing men are doing and switch to CASH-ACME.

A fact-jammed eight-page bulletin, with honest and accurate capacity charts, is available free of charge. Write today.



Type "B"—Rugged Industrial Type Pressure Reducing Valve . . . A truly *universal* piece of equipment. Standard models for:

- STEAM
- HOT WATER
- COLD WATER
- AIR
- LIGHT OIL
- NO. 6 OIL
- AMMONIA
- DIFFERENTIAL REGULATOR
- WITH INBUILT RELIEF
- AIR OR OIL TOP LOADING
- PANEL MOUNTING

FOR THE *Correct Answer*

CASH AUTOMATIC VALVES ACME

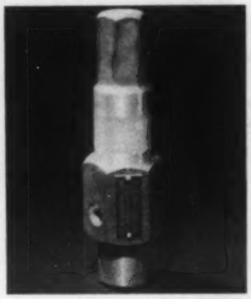
A. W. CASH VALVE MANUFACTURING CORP.
6613 E. Wabash Ave., Decatur, Illinois

sizes. Unit functions over a range approximately equal to the radius of the coil. It is designed for special applications requiring extra sensitivity where space is not a limiting factor, and can be used for industrial requirements, operating under conditions of oil, dust, moisture, vibration and a wide range of temperatures. **Electro Products Laboratories,** 4500 N. Ravenswood Ave., Chicago 40, Ill.

Circle 626 on page 19

Relief Valve

has full capacity at 25 per cent over-pressure



Series 44 hydraulic relief valve has full capacity at 25 per cent over-pressure. Long, soft spring design, narrow 45-deg seat and top and bottom disk guides provide quiet operation. Inner valve parts are corrosion-resistant stainless steel. Valve is well suited to aircraft, machine tools, food processing and refrigerating equipment. It is available in aluminum to 3500 psi and carbon steel and stainless steel to 10,000 psi, in $\frac{1}{4}$, $\frac{3}{8}$ and $\frac{1}{2}$-in. inlets and outlets. **Fluid Mechanics Co.,** P. O. Box 194, Bellaire, Tex.

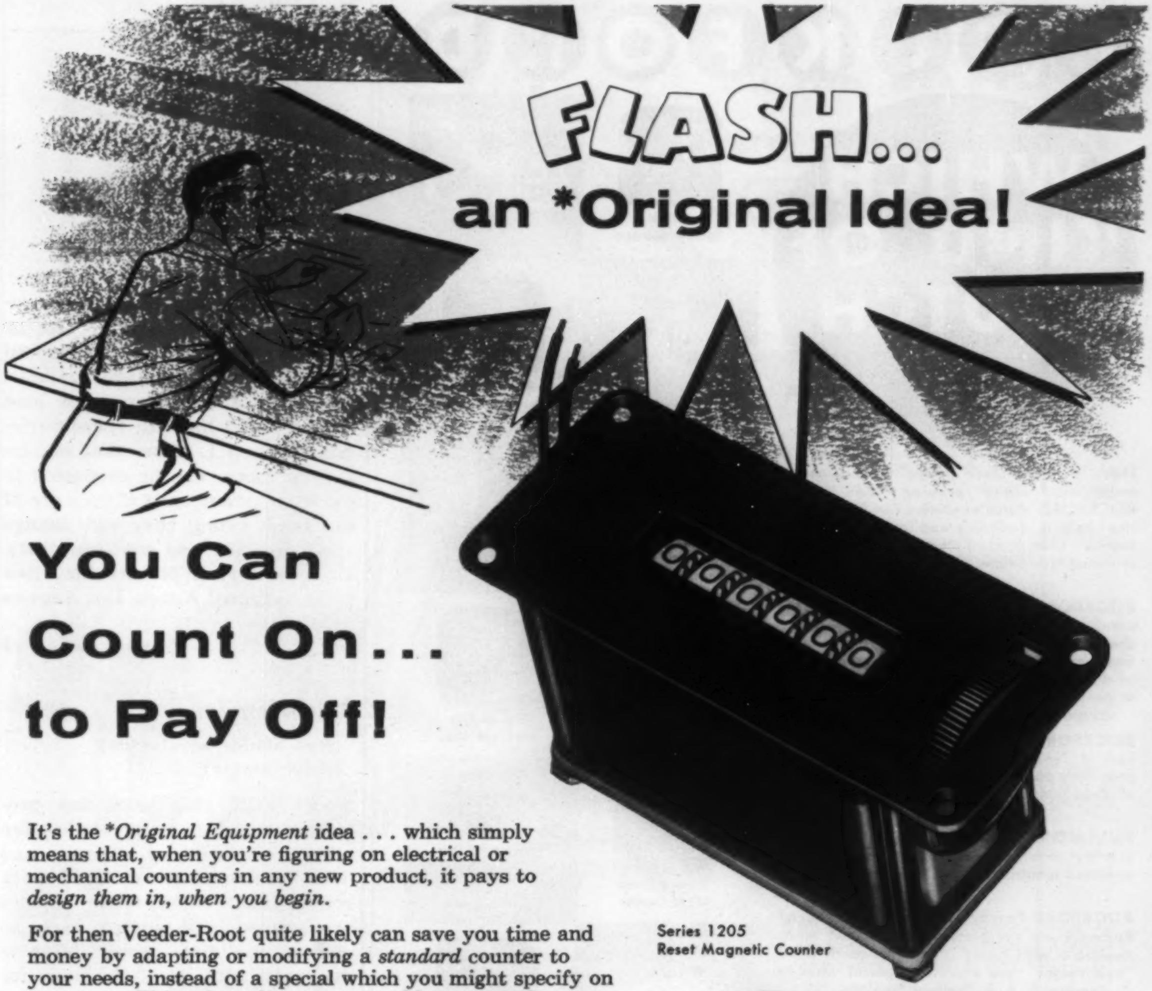
Circle 627 on page 19

Power Unit

converts ac motors to variable-speed units

Varidyne power unit converts any standard NEMA 3-phase ac induction motor from a fixed-speed type to a variable-speed drive. Speeds are changed at the power unit by a handwheel or remotely by mechanical or electrical controls. Unit is useful for applications where limited space, weight limitations,

Circle 477 on page 19


FLASH...
an *Original Idea!

You Can Count On... to Pay Off!

Series 1205
Reset Magnetic Counter

It's the **Original Equipment* idea . . . which simply means that, when you're figuring on electrical or mechanical counters in any new product, it pays to *design them in, when you begin.*

For then Veeder-Root quite likely can save you time and money by adapting or modifying a *standard* counter to your needs, instead of a special which you might specify on your own. This solves the counter problem . . . and saves you time in engineering, purchasing and assembly.

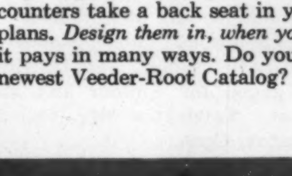
What's more, you give your product new sales-advantages: Direct-reading digits, instead of hard-to-read dials and verniers . . . instant remote indication if needed . . . up-to-the-minute performance records that serve as a basis for production-*Count*rol, and as proof of your performance guarantee. So don't let counters take a back seat in your new-product plans. *Design them in, when you begin . . .* it pays in many ways. Do you have the newest Veeder-Root Catalog? Write

Everyone Can Count on

Veeder-Root

INCORPORATED

Hartford, Conn. • Greenville, S. C. • Chicago • New York
Los Angeles • San Francisco • Montreal
Offices and Agents in Principal Cities



Series 1380
Box-Type Counter (Ratchet, Revolution, or Geared)

4-bank Counter for Radio Transmission Equipment

360-degree Bearing Counter

ROCKFORD

WHICH KIND OF CLUTCH ?

Small Spring Loaded
Automotive Spring Loaded
Heavy Duty Spring Loaded
Oil or Dry Multiple Disc
Production Equipment
Heavy Duty Over Center
For Road Machines
and Tractors
Light Over Center
Power Take-Offs
Speed Reducers

There is no one stock answer to every power transmission control problem. That is why ROCKFORD clutch engineers can be of practical help in designing applications that will increase your product's efficiency and reduce servicing down-time.

ROCKFORD Spring-Loaded CLUTCHES permit convenient control and smooth gear changes under conditions requiring almost constant engagement, with only short periods of disengagement—maintained by foot-pedal or hand-lever pressure.

ROCKFORD OVER-CENTER CLUTCHES lock in "engagement" or "release" position, providing positive control during long periods of engagement or disengagement operation.

PULLMORE Multiple-Disc CLUTCHES provide smooth starting and powerful, hand-operated control, within limited space.

ROCKFORD Power TAKE-OFFS and Speed Reducers are complete, self-contained units. Available with heavy duty, gear-tooth drive "over-center" type clutch equipment. Sizes to fit standard S. A. E. flywheel housings.

ROCKFORD Morlife® CLUTCHES are best suited for use in off-the-road machines such as tractors, trucks, tanks, cranes, shovels, bulldozers, earth movers, pipe layers, power units and other heavy duty equipment.

An engineered-to-the-job ROCKFORD CLUTCH application involves recommendations covering the proper type—spring-loaded, over-center, multiple-disc, gear-tooth or splined-to-shaft drive—as well as torque rating, shock-load absorption, slippage control, vibration dampening and provision for frequent drive shaft reversals.

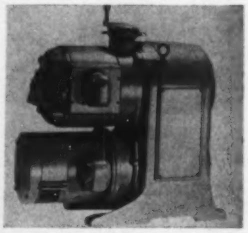
Regardless of your needs, ROCKFORD CLUTCH engineers can specify a size and type clutch that will operate most efficiently in your product—conserving space, power and final cost. Send a print or a description of your clutch need for their recommendations—

ROCKFORD Clutch Division BORG-WARNER
311 Catherine Street, Rockford, Illinois, U.S.A.
Export Sales Borg-Warner International — 36 So. Wabash, Chicago 3, Ill.

CLUTCHES

Circle 479 on page 19

New Parts



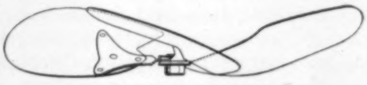
environmental hazards or other restrictions eliminate the use of other types of variable-speed drives. Power units are available to handle a total connected load from 1 to 50 hp with speed variations up to 5:1. More than one induction motor can be connected to the same power unit; if they are of the same rating they will change speeds equally and simultaneously. **U. S. Electrical Motors Inc.**, Box 2058, Terminal Annex, Los Angeles 54, Calif.

Circle 628 on page 19

Axial-Flow Fan

has blades overlapping drive motor

Model YOX 20-3 axial fan provides reduced depth in window-fan units while avoiding vibration and noise problems encountered with conventional offset fans. Blades are shaped and angled back to overlap the drive motor. Fan is available with a 20-in. diameter and standard blade depths of $2\frac{3}{8}$, 2 31/32 and 3 17/32 in. Standard construction is mill-finished aluminum blades, steel spider and rubber-bushed hub. Blades are statically balanced and individually gaged for contour and alignment. **Torrington Mfg. Co.**, Torrington, Conn.



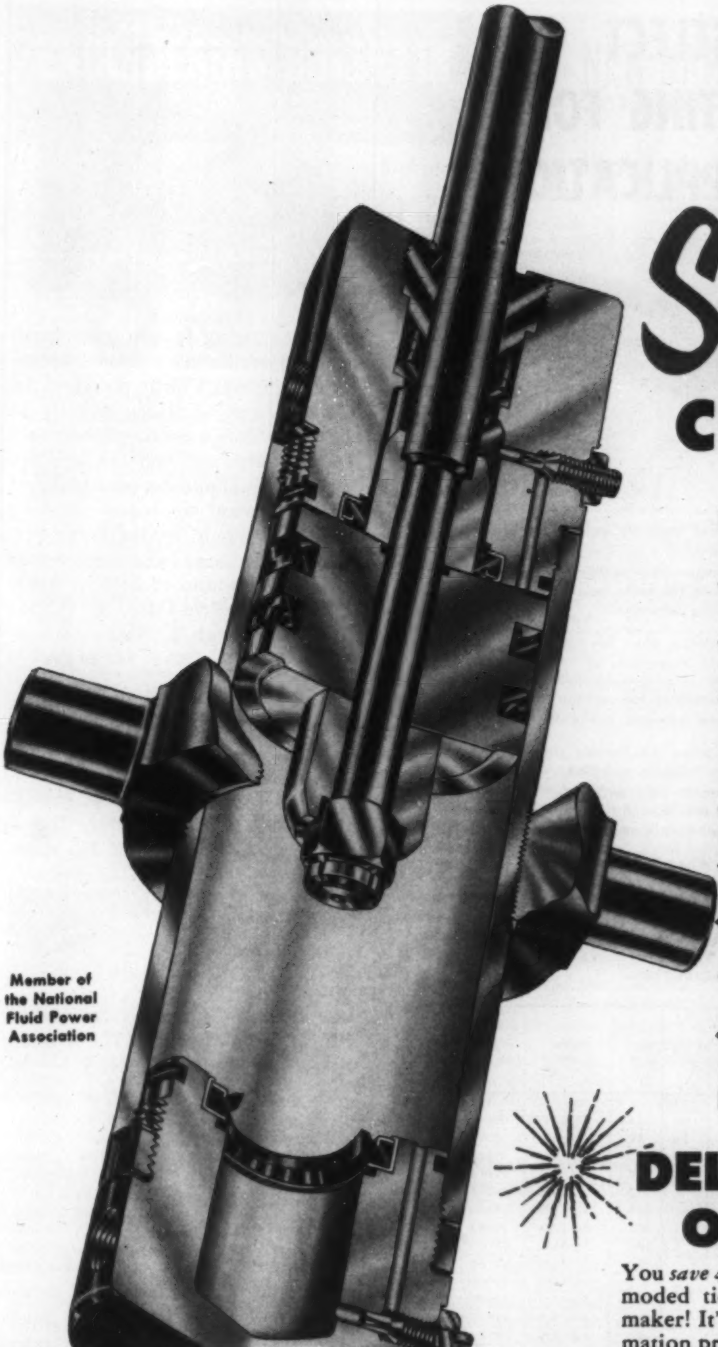
Circle 629 on page 19

Ring-Type Core

for toroidal coil designs

Resin - insulated ring-type core made from grain-oriented Hipersil steel in all gages from 1 to 12 mils thick is used for toroidal core

all the **EXTRAS**
are standard with
T-J Spacemaker
CYLINDERS



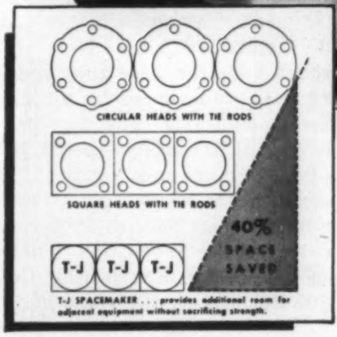
Member of the National Fluid Power Association

- **NEW** *exclusive* ingenious cushion designs . . . Super Cushion Flexible Seals for Air . . . New Self-Aligning Master Cushion for Oil.
- **STRONGER** than outmoded tie rod design, proven through actual tests. No tie rods to stretch.
- **SOLID STEEL HEADS** throughout the full line.
- **COMPACT DESIGN** eliminates tie rods, increasing the strength and reducing mounting space required, providing extra room for adjacent equipment.
- **HARD CHROME PLATED** body bores and piston rods . . . assure you of long trouble-free service. (Standard at no extra cost.)
- **METALLIC ROD SCRAPER**, not just a wiper, actually removes foreign matter from the rod.
- **PILOTED PACKING GLAND** with extra long bearing. Additional strength and support to the piston rod.
- **OIL** pressure to 750 p.s.i. AIR to 200 p.s.i.

DELIVERY OFF THE SHELF!

You *save 40% space* when you switch from outmoded tie rod cylinders to the T-J Spacemaker! It's stronger, too! Fits right into automation programs in countless plants. Delivers top performance and dependability with a big *plus* in advanced features. Wide range of styles, capacities . . . reduces man-hours and costs in all kinds of push-pull-lift operations. Off-shelf delivery in 64,000 combinations!

NEW LITERATURE—Send today for new Catalog SM56 with complete engineering details on Spacemaker line. Write The Tomkins-Johnson Co., Jackson, Mich.

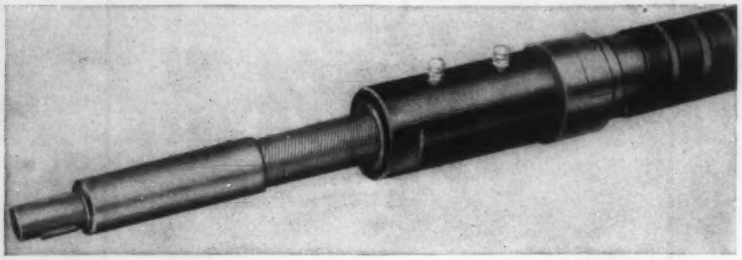


T-J SPACEMAKER . . . provides additional room for adjacent equipment without sacrificing strength.

Spacemaker

T-J **TOMKINS-JOHNSON**
RIVITORS · AIR AND HYDRAULIC CYLINDERS · CUTTERS · CLINCHORS

HOW TO SELECT FLEXIBLE SHAFTING FOR POWER DRIVE APPLICATIONS



1¼-inch STOW Power Drive flexible shaft with core assembly pulled out of casing.

For Power Drive applications, the following factors must be considered:

1. Torque (Lb. In.) to be transmitted. (The starting torque should be used in making selections).

2. Operating Speeds (RPM) — If the maximum speed is higher than the rated speed, torque ratings in the table below do not apply. To find the torque capacity for flexible shafts operating at speeds higher than the rated speeds, multiply the maximum dynamic torque capacity by the rated speed, and then divide by the operating speed. (See example).

3. Operating Radius-In making the selection from the table below, the radius of the smallest bend in the flexible shaft should be used.

Ratings — The ratings for flexible shafts shown in the table below apply under the following conditions:

1. When the flexible shaft is adequately supported by clamps along its length. (For unsupported shafts, multiply the calculated torque by a safety factor of 1.6—see example below)

2. When the flexible shaft is operated in the wind-up direction, which tends to tighten the outer layer of wires. (Flexible shafts operated in the unwind direction will transmit only about 60% of the rated torque).

3. When the flexible shaft is in continuous operation. Note: **the ratings are based on temperature rise. When the operation is intermittent, the ratings in the table may be exceeded. Consult Stow Engineers for specific recommendations.**

RATED SPEED R.P.M.	MAXIMUM DYNAMIC TORQUE CAPACITY (LB. IN.)									Wgt./ C. Ft.	Core Dia.	Core No. and Type	Shaft Size
	STRAIGHT AND CURVED SHAFTS												
	RADIUS OF CURVATURE IN INCHES												
	50 to Strgt.	25	20	15	12	10	8	6	5				
4,500	2.4	2.2	2.0	2.0	1.92	1.9	1.7	1.5	1.25	3.0	.124/.128	2049 MH	13
3,800	7.0	6.4	6.0	5.8	5.4	5.0	4.6	3.6	2.0	4.5	.148/.152	2081 MH	15
2,900	9.4	8.6	8.0	7.6	7.0	6.6	6.0	4.8	3.4	7.0	.185/.189	5108 MH	19
2,500	22.0	20.0	18.8	17.6	16.0	15.0	12.6	10.8	9.0	12.5	.247/.252	8924 MH	25
1,800	30.0	28.0	26.4	25.0	23.0	21.0	18.0	14.0		20.0	.308/.313	8925 MH	31
1,800	33.8	31.5	29.7	28.1	25.9	23.6	20.2	15.8		20.0	.308/.313	8969 T	31
1,800	36.0	33.0	31.6	30.0	28.0	26.0	22.0	18.0	11.0	21.0	.324/.329	2034 A	31
1,500	80.0	66.0	63.0	58.0	51.0	46.0	37.0	22.0		28.5	.368/.374	2035 A	38
1,500	60.0	54.0	50.0	46.0	42.0	38.0	30.0	24.0		29.0	.387/.393	8970 MH	40
1,500	90.0	81.0	75.0	69.0	63.0	57.0	45.0	36.0		29.0	.387/.393	8971 T	40
1,150	136.0	110.0	104.0	94.0	80.0	72.0	56.0			50.5	.497/.503	8999 A	50
1,150	148	124	110	92	72	56				53.5	.505/.511	6940 T	50
900	248	200	176	124	84					78.5	.610/.618	6997 T	63
900	220	204	192	180	152	130				80.5	.630/.638	7731 A	63
750	340	224	156	76						117	.747/.753	2056 T	75
600	760	520	420							205	.998/1.004	2057 T	100
440	1,500	720								343	1.298/1.304	2058 T	125

If you have a specific design problem you wish to discuss, you can consult with our Chief Engineer, Mr. G. G. Eisenbeis, and other Stow flexible shaft engineers at our Booth #302 at the coming Design Engineering Show, May 20-23 at the New York Coliseum.

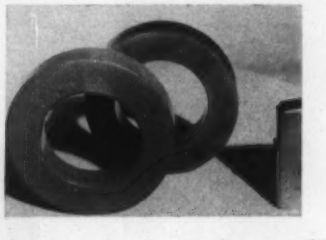
For Engineering Bulletin No. 570 and a free torque calculator, write

STOW MANUFACTURING COMPANY

11 Shear Street • Binghamton, New York

Circle 481 on page 19

New Parts



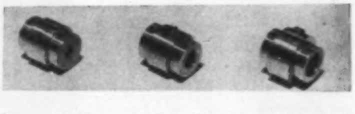
designs ranging in size from small blocking-oscillator pulse transformers through large power units. Windings can be placed directly on the core. Resin coating is continuous and smooth, and corners are rounded to eliminate possibility of shorting wire to core. Coating does not impair magnetic properties of the core and withstands voltage to ground of 2500 v. **Westinghouse Electric Corp.**, P. O. Box 2099, Pittsburgh 30, Pa.

Circle 630 on page 19

Gear Cluster Hubs

of 303 stainless steel

Type BH precision gear cluster hubs are used as adapters for J-type gears. They are of 303 stainless steel and are clear passivated. **PIC Design Corp.**, 477 Atlantic Ave., East Rockaway, N. Y.



Circle 631 on page 19

Variable-Speed Drive

operates from 23 to 2300 rpm

Redesigned VS Jr. variable-speed electronic drive consists of a rectified-power control panel, operator's station, and variable-speed drive motor. Available in 220 and 440-v units in sizes from ¾ through 4 hp, the drive gives wide-range adjustable speed for all machine applications requiring precise control of variable speeds, including inching and jogging. It operates from as low as 23 rpm for intermittent duty to 2300 rpm for high-speed production. **Reliance Electric & Engineering Co.**, 24701 Euclid Ave., Cleveland 17, O.

Circle 632 on page 19

ENGINEERING BULLETIN
ON MICRO-BEARINGS
Miniature Instrument Ball Bearings

NEW HAMPSHIRE BALL BEARINGS, INC.
PETERBOROUGH 1, NEW HAMPSHIRE

Subject: RADIAL AND AXIAL PLAY

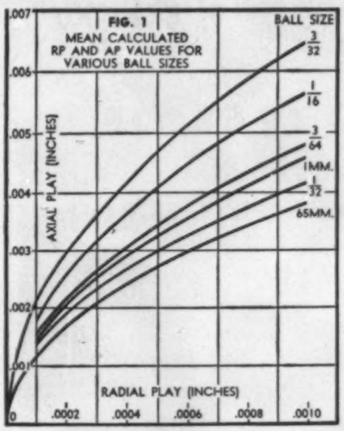
This bulletin explains the interrelation between radial play, axial play and contact angle in small instrument type ball bearings, and assists in specifying these characteristics correctly for typical applications.

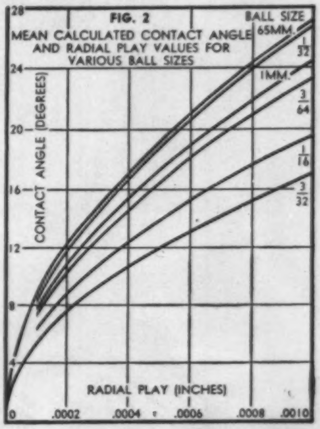
DEFINITIONS

Radial play is the maximum possible radial displacement of the inner ring with respect to the outer ring when the bearing is unmounted. *Axial play* is the maximum possible axial displacement of the inner ring with respect to the outer ring when the bearing is unmounted. *Contact angle* is defined as the angle between a plane perpendicular to the bearing axis and a line connecting the two points on a given ball where it makes contact with the raceways under a condition of pure thrust load.

Radial play, axial play and contact angle are geometrically interrelated, but since radial play is the most readily measurable, it is the characteristic usually specified.

In *Fig. 1*, values of axial play resulting from a given radial play and ball size, are given for reference purposes.





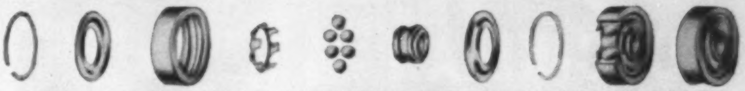


FIG. 5. *Typical Micro-Bearing of the shielded type shown in exploded, cut-away and fully assembled views.*

SPECIFYING RADIAL PLAY

Two fundamental considerations must be established before arriving at a correct radial play specification: (1) the direction of the load imposed on the bearing, and (2) the axial play control, if necessary for the proper functioning of the unit. This is ultimately a problem of considering the contact angle resulting from a given radial play. High radial play is associated with high contact angle. This relationship is illustrated on *Fig. 2.*

TYPE OF LOAD

If there is a measurable *axial load*, such as is encountered with bevel gearing, or in an application such as illustrated in *Fig. 3*, the bearings should operate at a high contact angle. Under such circumstances, a radial play of .0005 to .0008 is recommended.

If the application involves a *pure radial load*, such as in the case of spur gears *(Fig. 4)*, there is no concern with contact angle, since it will be zero.

LOW RADIAL PLAY

Functional requirements of the application will dictate whether the radial play is low or standard. However, before *low* radial play is specified, the following factors must be considered:

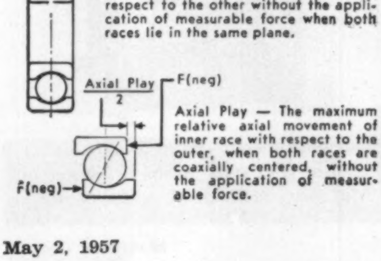
1. *A bearing with low radial play should not be subjected to interference fitting. This causes reduction in radial play which may create excessive preload resulting in early bearing failure.*
2. *Low radial play results in a low allowable angle of misalignment. An important feature of a ball bearing is its ability to adjust itself internally to possible housing misalignment, particularly when through-boring is not possible.*

There is one situation, however, where low radial play is recommended. If the bearing is to be subjected to very high repetitious radial shock loads, low radial play minimizes the possibility of bearing damage by distributing the load over a greater number of balls.

AXIAL PLAY CONTROL

If a design calls for axial play values of .002 or less and the bearings are to be used to limit axial travel, it is *not* good practice to achieve this by specifying low radial play. The design should provide for external means of adjustment such as shims. For such cases, the recommended radial play is from .0005 to .0008.

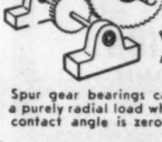
Great care should be exercised if any means other than a calibrated spring is employed to take out *all* axial play. Preloading, with its many complications, may result. Zero axial play automatically yields zero radial play. A high radial play, such as .0005 to .0008, is recommended in cases where axial play is to be reduced to zero by external means.



Radial Play — Maximum distance one race may move diametrically with respect to the other without the application of measurable force when both races lie in the same plane.

Axial Play — The maximum relative axial movement of inner race with respect to the outer, when both races are coaxially centered, without the application of measurable force.

FIG. 4



Spur gear bearings carry a purely radial load where contact angle is zero.

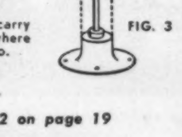


FIG. 3

Weather vane bearing carries purely thrust load and normally involves high contact angle and high radial play.

RADIAL PLAY SPECIFICATION

There is a misconception among many bearing users that radial play is automatically considered under the ABEC classification. Such is not the case.

However, standard "MICRO" bearings are assembled with a radial play of not less than .0002 nor greater than .0008, unless so ordered. If this range of .0002 to .0008 is acceptable in the application, it is recommended that *No Radial Play Specification* be placed on the bearing.

Radial play is specified most conveniently by a tolerance range. Thus, while the radial play of a given bearing might be .00036, it is more convenient to represent this value as .0002 to .0005. Detailed instructions for specifying other than standard radial play values are incorporated in our catalog.

Since radial play is determined during the bearing manufacturing, specifications of other than standard values should be considered carefully at the design stage, as it may result in delay in assembly and delivery.

DESIGNERS HANDBOOK *OFFERED FREE* TO ENGINEERS

If you work with miniature bearings, you'll find this new, 70 page authoritative publication a great help in designing instruments or small electro-mechanical assemblies.

It will be sent free to engineers, draftsmen and purchasing agents.

Write: New Hampshire Ball Bearings Inc., Peterborough 1, N. H.

Micro Bearings

Circle 482 on page 19

NEW!
Super
AUTO-KLEAN

NO ONE FILTER MEETS ALL DESIGN NEEDS . . .

and Only CUNO offers you

5 DISTINCT TYPES OF FILTER MEDIA

◆ EDGE-TYPE ◆ WIRE-WOUND ◆ SCREEN
◆ FIBER CARTRIDGE
◆ POROUS METAL

consider

Super AUTO-KLEAN

where filter design calls for

- ◆ MICRONIC FILTRATION . . . down to 40 microns
- ◆ POSITIVE, SELF-CLEANING ACTION . . . no "down time"
- ◆ SMALL SIZE plus HIGH FLOW RATES . . . 12" unit shown here handles over 50 gpm
- ◆ LOW PRESSURE DROP . . . less than 3 psi

All-metal construction,
carbon or stainless steel.
Two-stage filtration. Lowest cost-per-gallon.

COMPLETE DESIGN-ENGINEERING SERVICE

There is a Cuno Field Engineer conveniently located in your area. To help you solve your design problems, this trained specialist offers you *more years of experience* in removing *more sizes of solids* from *more kinds of fluids*.

WRITE FOR DATA

Send now for your free copy of Cuno Catalog No. SAK-057 containing complete engineering data. See how this high-performance filter can help your designs achieve new efficiency.

CUNO

CUNO ENGINEERING CORPORATION
1405 SOUTH VINE STREET, MERIDEN, CONN.
Filtration Engineers in Principal Cities

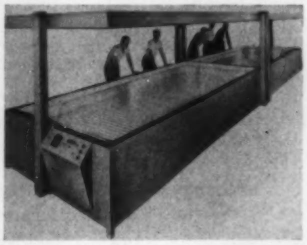
Circle 483 on page 19

ENGINEERING DEPARTMENT EQUIPMENT

Contact Printer

makes master layouts and templates

Fluorescent contact printer, 72 x 360 in. in size, makes master layouts and templates by photographic methods. Templates are produced on metal, plywood, plastic and other materials from a master layout drawn on glass cloth. Sensitized template and glass cloth are brought into absolute contact by sealing action of a heavy rubber blanket when vacuum pressure is applied. Template is subjected to intense light of 120 fluorescent tubes, then removed from the machine and subjected to a developing and fixing process. **Miller-Trojan Co. Inc.**, Troy, O.

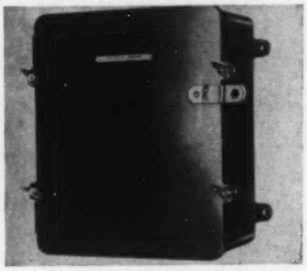


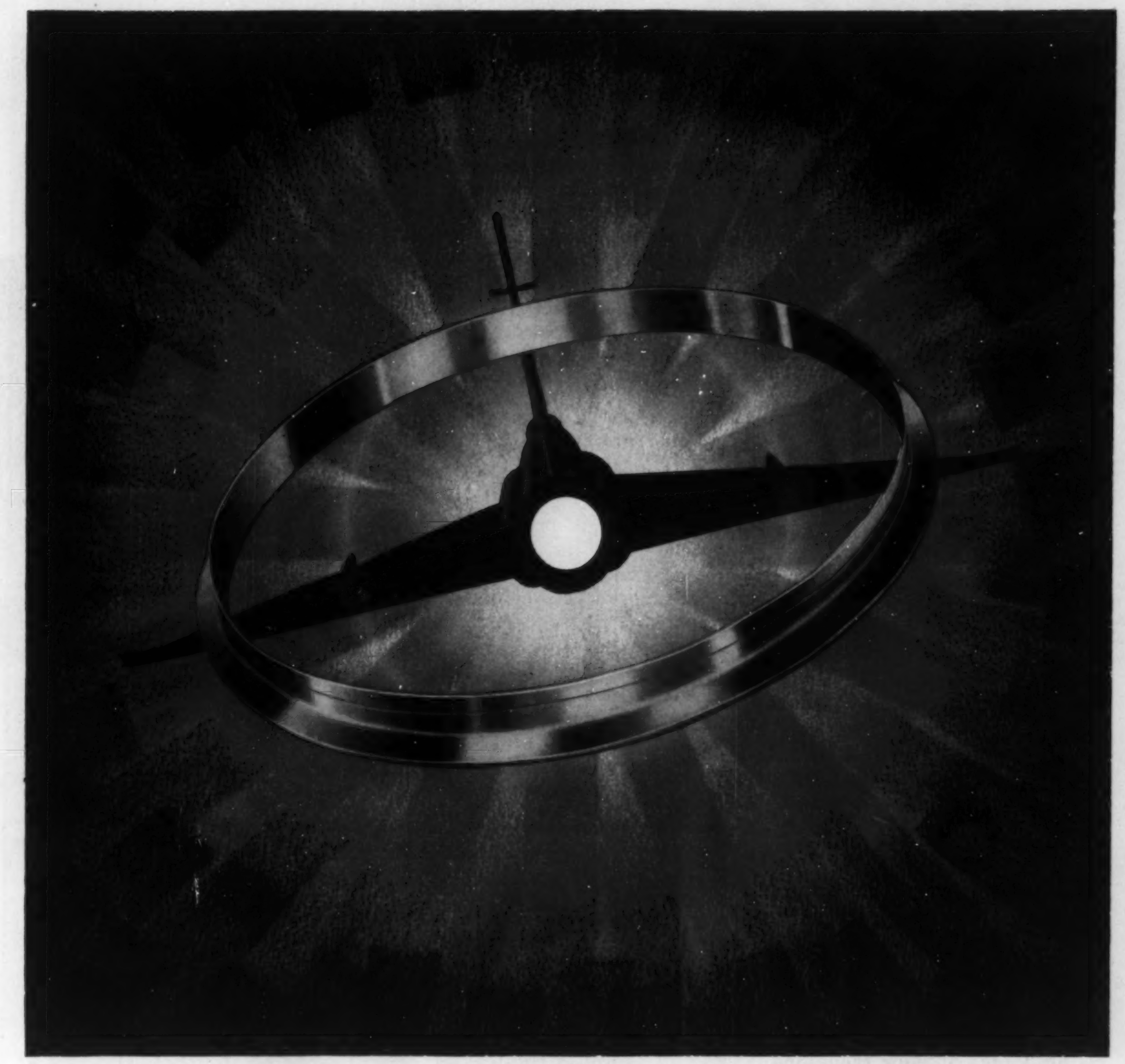
Circle 633 on page 19

Recording Gages

for outdoor mounting

These recording gages for pressure, vacuum, water or liquid-level measurements have weatherproof cases for wall or pole mounting outdoors. Measurements of water





Cool Performance In A Hot Engine

Major U. S. manufacturers of jet aircraft engines have learned to depend on American Welding rings and circular components of stainless steel, titanium or other special alloys to solve many of the problems created by the requirements of today's supersonic performance.

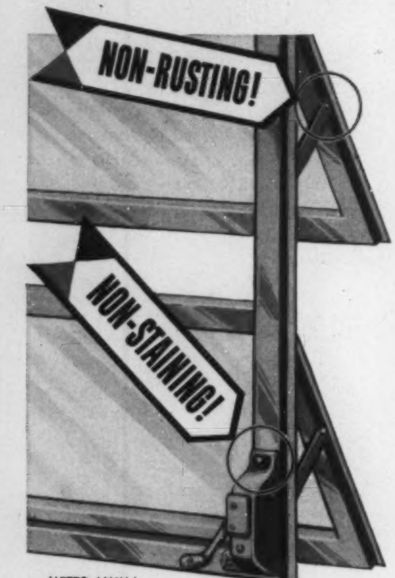
American Welding is equipped to form, weld, fabricate and machine rings and weldments from 6" to 96" in diameter.

Why not contact American Welding's Industrial Products Division to talk about rings and components where top performance is required.

THE AMERICAN WELDING & MANUFACTURING CO.
130 Dietz Road • Warren, Ohio

AMERICAN WELDING
The World's Leading Manufacturer of Welded Rings

How Alcoa Aluminum Fasteners make good windows even better


NON-RUSTING!
NON-STAINING!

MEETS AWMA STANDARDS!

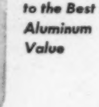
You can meet the highest standards of quality and the specifications of the AWMA (Aluminum Window Manufacturers Association) for prime windows of aluminum when you assemble with Alcoa® Aluminum Fasteners. Perfect color match and protection against both galvanic and atmospheric corrosion make for lasting good looks . . . consumer satisfaction. Complete stocks carried by your local Alcoa distributor fill every requirement. He is listed in the Yellow Pages of your telephone directory.

ALCOA ALUMINUM FASTENERS
ALUMINUM COMPANY OF AMERICA
®ALCOA

Your Guide to the Best in Aluminum Value

THE ALCOA HOUR
TELEVISION'S FINEST LIVE DRAMA
ALTERNATE SUNDAY EVENINGS

Fill out coupon for facts, samples



Aluminum Company of America
2244-E Alcoa Bldg., Pittsburgh 19, Pa.
Gentlemen: Please send complete specification data and samples of Alcoa Aluminum Fasteners.
Name__________
Title__________
Company__________
Address__________

Circle 485 on page 19

depths or other liquids can be accomplished with float-type, pressure-type, differential-pressure-type or bubbler-type liquid-level gages. Pressure gages are offered in all ranges. Both 8 and 12-in. round chart models are available in the waterproof cases. Flowmeters and thermometers are also offered. **Bristol Co.**, Waterbury 20, Conn.

Circle 634 on page 19

Tracing Paper

accepts pencil hardness to 9H

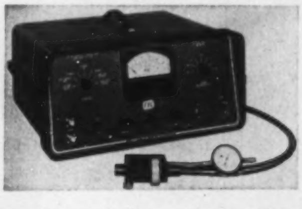
Visi-Vel resin-transparentized, full rag content tracing paper provides good visibility of drawing surface and line when used for original drawing and excellent visibility of underlying image when used for tracing. Paper accepts pencil hardness to 9H without tearing or puncturing, and areas can be erased and re-erased cleanly without damaging drawing qualities. It can also be used with ink. Drawings can be filed indefinitely without deterioration since paper does not become brittle or discolor with age, is oil, leach and odor-free and resists ghosting. It is available in thin, medium and heavy thicknesses in all sheet sizes and in 20 or 50-yd rolls. **Charles Bruning Co. Inc.**, 4700 W. Montrose Ave., Chicago 41, Ill.

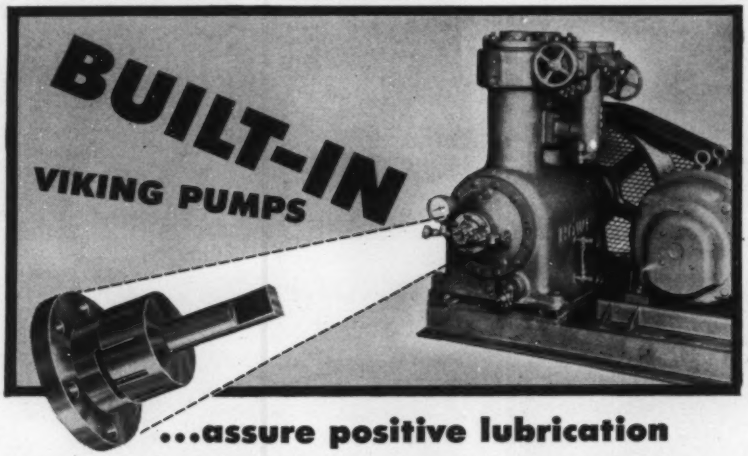
Circle 635 on page 19

Vibration Calibrator

measures vibrations of 10 to 20,000 cps

Model 501 vibration calibrator measures, with accuracy of ± 5 per cent, vibration amplitudes of non-magnetic metals such as copper, brass and aluminum while utilizing a minimum surface diameter of $\frac{7}{8}$-in. It can also be used on





...assure positive lubrication

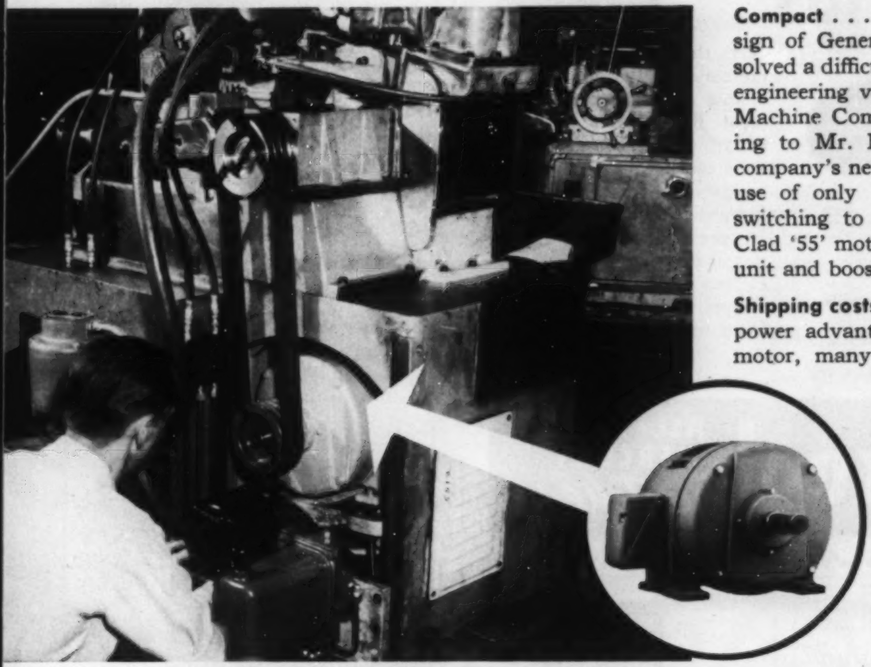
Howe Ice Machine Company of Chicago, Illinois, uses built-in Viking Pumps to assure positive lubrication of compressor bearings, pistons and cylinder walls. Their system incorporates a Viking 3½ gpm rotor, head and idler into an integral casing. They are rugged pumps, serving dependably 10 to 20 years. Used by Howe since 1921, Vikings have proved so satisfactory that other manufacturers have since used similar pumping systems. If you are using or planning equipment that could use built-in pumping, investigate Vikings. To start, see your distributor, or write for bulletin 57Sh.

VIKING PUMP COMPANY
Cedar Falls, Iowa, U.S.A. In Canada, it's "ROTO-KING" pumps
THE ORIGINAL "GEAR-WITHIN-A-GEAR" ROTARY PUMP

Circle 486 on page 19

"We switched to the compact G-E TRI 55 CLAD motor and boosted power by 50%"

REG. U.S. PAT. OFF.

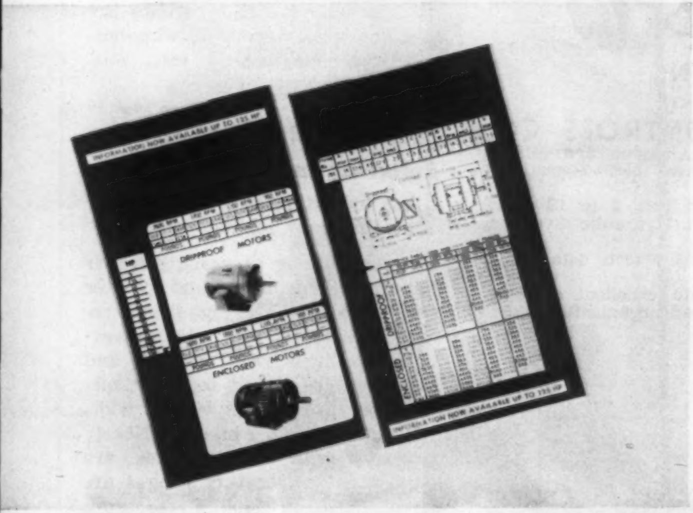


Compact . . . power-packed—The compact design of General Electric's Tri-Clad '55' motor solved a difficult power problem for Roger Pyne, engineering vice-president of the Van Norman Machine Company, Springfield, Mass. According to Mr. Pyne, "space limitations on the company's new centerless grinder permitted the use of only a 5-hp conventional motor. By switching to the smaller, more compact Tri-Clad '55' motor we were able to go to a 7½-hp unit and boost our grinder's capacity by 50%."

Shipping costs reduced 40%—In addition to the power advantages of the smaller Tri-Clad '55' motor, many companies are finding that the lighter, easier-to-handle motor has cut shipping and handling costs as much as 40%. Contact your nearest General Electric Apparatus Sales Office to learn the many years-ahead benefits that the new Tri-Clad '55' motor can bring to your product . . . to your operation.

FREE SLIDE RULE

ADVANCE INFORMATION TO HELP YOU PLAN AHEAD


INFORMATION NOW AVAILABLE UP TO 125 HP
DRIPPROOF MOTORS
ENCLOSED MOTORS
INFORMATION NOW AVAILABLE UP TO 125 HP

WRITE FOR FREE SLIDE RULE which lets you determine at a glance the weight and space benefits of recently announced NEMA standards for larger motors. This handy slide rule provides advance information to solve your design problems . . . to benefit your overall operation.

Circle 487 on page 19

SECTION C891-1
GENERAL ELECTRIC COMPANY
SCHENECTADY 5, NEW YORK

I want advance information on new NEMA dimensions for larger motors. Please send me free slide rule.

NAME ____________________

COMPANY ____________________

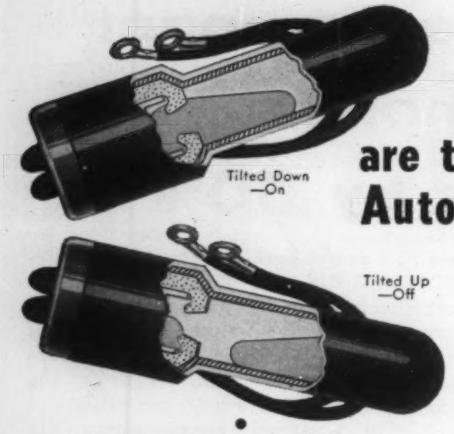
ADDRESS ____________________

CITY & STATE ____________________

TITLE ____________________

Progress Is Our Most Important Product

GENERAL ELECTRIC



DURAKOOL
Tilt Switches
are the Life of your
Automatic Controls

This steel-clad Durakool mercury tilt switch has unique construction features that deliver years of trouble-free performance on the most difficult assignments you can find. Operating under sealed-in, pressurized hydrogen gas, it takes 24 hours, fast cycling schedules in stride. 7 sizes, 1 to 65 amperes. Send for Bulletin 525.

•
MILLIONS OF CYCLES
WITHOUT FALTERING
•

See telephone directory for local distributor, or write.
DURAKOOL, INC.
ELKHART, INDIANA, U.S.A.
700 WESTON RD., TORONTO 9, CANADA

® Durakool ALL-STEEL MERCURY Switches

Circle 488 on page 19

MECHANICAL
ENGINEERS

OUTSTANDING POSITIONS
with the Aeronautical Division of
ROBERTSHAW-FULTON CONTROLS CO.

. . . in the design and development of Airborne and Missile Pneumatic and Hydraulic Control Systems, and Mechanical Components.
Graduate Mechanical Engineers are needed with 2 to 10 years experience in Servo Techniques, Pneumatic/Hydraulic Systems, Thermodynamics or similar fields.
Send today for your copy of our brochure which details our facilities and your opportunity with us.
Comfortable Southern California living and excellent working conditions make the Aeronautical Division an organization you'll want to join.

Contact:
Lawrence R. Bigbee
Dir. of Engineering Placement
419 N. Manchester Ave.
Anaheim, Calif.

PRODUCTS FOR PROGRESS BY THE MEN OF AERONAUTICAL

Aeronautical Division
Robertshaw-Fulton
CONTROLS COMPANY

Circle 489 on page 19

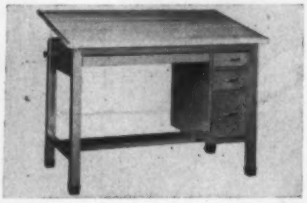
magnetic metals and nonmetallic surfaces by cementing a piece of copper or aluminum foil 0.01-in. thick and 1 in. in diameter to the surface under the transducer. The calibrator measures vibrations of 10 to 20,000 cps with amplitudes of 20 to 20,000 mu in. Precision attenuator privides ranges of 0.02, 0.06, 0.2, 0.6, 2, 6 and 20 thousands of an inch. **Tel-Instrument Electronics Corp.**, Carlstadt, N. J.

Circle 636 on page 19

Drafting Tables

have all-steel bases

Four-post drafting tables have steel bases and drawers and solid basswood tops with heavy-gauge steel end cleats. Table legs are equipped with skidproof leveling devices. Metal drawers glide on ball-bearing rollers. Five combinations are available with different arrangements of the basic table, tool drawer, shallow drawer, auxiliary-drawer unit and plan file. Tables are available with various drawing-surface izes. **Mayline Co. Inc.**, Sheboygan, Wis.



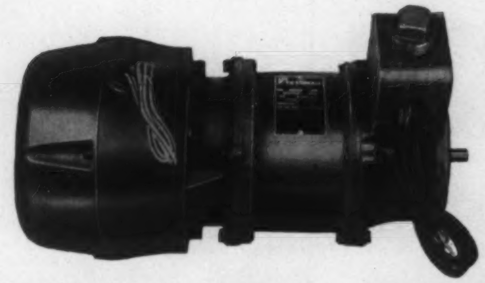
Circle 637 on page 19

Recording Instrument

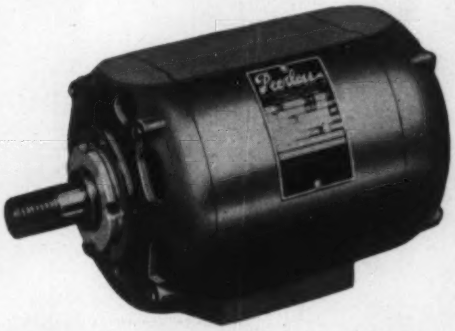
has indicating
dial for easy reading

Temperature or pressure recorder has indicating scale and pointer that indicates reading being recorded on chart. Only one measuring element is used; pointer and pen arm are linked together mechanically. Recorder is 9 in. wide, 10¾ in. high and 2 in. deep. Nearly 100 different chart ranges are available. Temperature ranges are from −200 to 1000 F; pressure instruments are available to 2000 psig. **Dickson Co.**, 7422 Woodlawn Ave., Chicago 19, Ill.

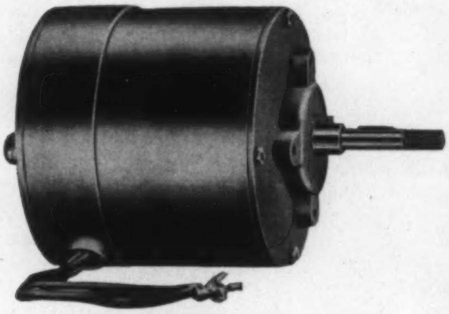
Circle 638 on page 19



EXPLOSION-PROOF TORQUE MOTOR WITH BRAKE



COMPACT DESIGN RADIAL SAW MOTOR



NAVY MOTOR—SPRAY-TIGHT

SPECIAL MOUNTED VERTICAL MOTOR

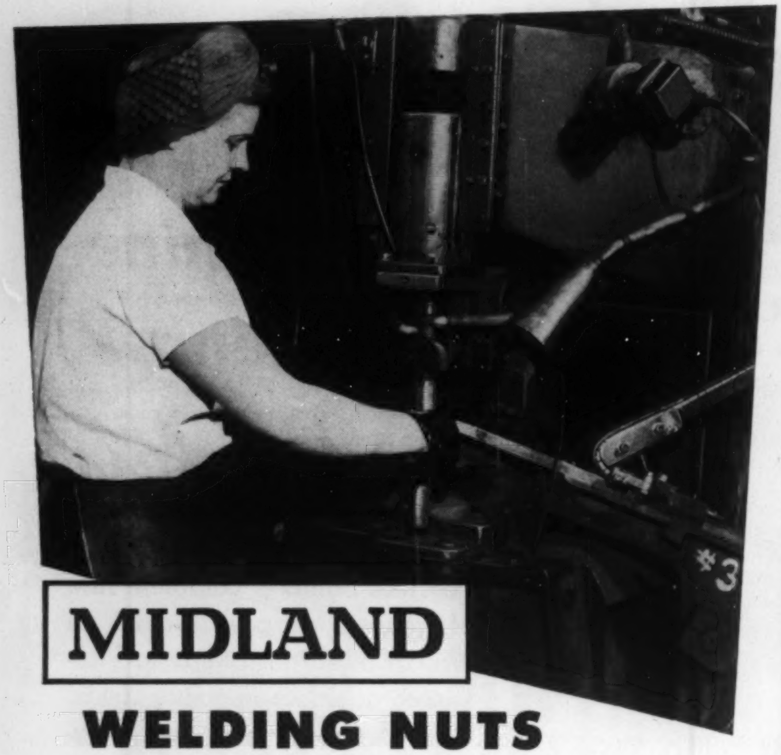
If stock motors cut machine efficiency see *Peerless*

Peerless builds a complete line of general purpose motors as well as hundreds of specials designed to meet specific needs. Our engineers have wide experience in applications of all types, and specialize in solving motor problems for design engineers who require unusual mountings or unusual construction to achieve maximum machine efficiency. Consult your nearby Peerless representative or write directly to us about any motor problem. We'll work with you to develop the one motor that powers your equipment best. Write for Bulletin SDA-155 now.

Single phase
½ thru 7½ HP

Polyphase
½ thru 30 HP

ELECTRIC MOTOR DIVISION
THE *Peerless Electric*® COMPANY
FANS • BLOWERS • MOTORS • ELECTRONIC EQUIPMENT
1520 W. MARKET ST • WARREN, OHIO



MIDLAND

WELDING NUTS

Cut Assembly Time . . .
Insure Proper Fit of Metal Parts

Modern designers of metal parts are finding Midland Welding Nuts a simple, low-cost means of insuring strong, bolted unions at hard-to-get-at places. Once the nut is welded into position at the exact location, the bolt can be easily turned into it without requiring a holding device on the nut. This not only means a saving in assembly time, but often results in one man being able to do a job previously requiring two.

If you're a manufacturer of metal parts, you can enhance your product appeal and at the same time pass along substantial savings to your customers if you use Midland Welding Nuts. By equipping your product with these lock-sure nuts, assembly flows uninterruptedly and parts fit accurately. Welding nuts are applied in a matter of minutes, last the long life of your product.

Inquire about this economical convenience today. You'll find it pays for itself over and over again.

The MIDLAND STEEL PRODUCTS COMPANY
6660 Mt. Elliott Avenue • Detroit 11, Michigan
Export Department: 38 Pearl St., New York, N. Y.
AUTOMOBILE and TRUCK FRAMES • AIR and VACUUM POWER BRAKES
AIR and ELECTRO-PNEUMATIC DOOR CONTROLS

THE ENGINEER'S Library

Recent Books

Introduction to the Basic Mechanisms. *By Roy E. Hampton, department of marine engineering, U. S. Naval Academy; 250 pages, 6 by 9 in., clothbound; published and available from U. S. Naval Institute, Annapolis, Md.; $4.50 per copy.*

This book covers the fundamentals of mechanisms and their variations, combinations, and interrelationships. Mechanisms discussed include four-bar linkages, rolling bodies, cams, gears and gear trains, screws, and universal joints. Also discussed are vectors, acceleration, and velocity. Both mathematical and graphical solutions are given.

Mechanics for Engineers: Statics and Dynamics. *By Ferdinand P. Beer and E. Russell Johnston Jr., both of Lehigh University; 710 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN*; $8.00 postpaid.*

This book provides a simplified approach by dividing mechanics into the mechanics of particles and the mechanics of rigid bodies. It takes up operations with forces, then applies the concept of equilibrium to problems involving particles, thus introducing practical situations early in the text. The statics of rigid bodies is considered both in two and three dimensions. In the applications of statics to bodies and structures, the principal emphasis is on equilibrium. In dynamics, the three basic methods of analysis are first applied to problems involving only particles, so that their respective advantages are discussed before the subject of the motion of rigid bodies.

Vibration Analysis Tables. *By R. E. D. Bishop and C. D. Johnson; 64 pages, 8½ by 11 in., paperbound; published by Cambridge University*

Circle 491 on page 19

Press, 32 East 57th St., New York 22, N. Y.; available from MACHINE DESIGN, $2.00 *postpaid.*

Calculation of the natural frequencies of vibration of engineering structures and mechanisms is frequently of importance to designers. Calculation of the response of these systems to harmonic excitation may also be of value. The work may be simplified by the tabulated functions and standard formulas listed in this book. The theory upon which this technique is based involves the concept of "receptance" which is comparable with that of "admittance" in electric circuit theory. The receptance of a system is a measure of its readiness to respond to harmonic excitation.

Government Publications

Investigation of the Nature of the Forces of Adhesion, PB 121555. *By L. Brantley and J. Charnell; 89 pages, 8½ by 11 in., paperbound; prepared by Department of Chemistry, Occidental College, Los Angeles; available from Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C.; $2.25 per copy.*

Many methods have been devised for the measurement of adhesion by coating-substrate separation. This investigation reviews the latest refinements in technique and interpretation from use of the Interchemical Adherometer, a chisel-type instrument which measures the force necessary to scrape off a coating of certain width from the substrate. Evaluation of bulk shear through the friction properties of the coating receives particular attention.

NACA Technical Series. *Each publication is 8 by 10½ in., paperbound; copies available from National Advisory Committee for Aeronautics, 1924 F St., N.W., Washington 25, D.C.*

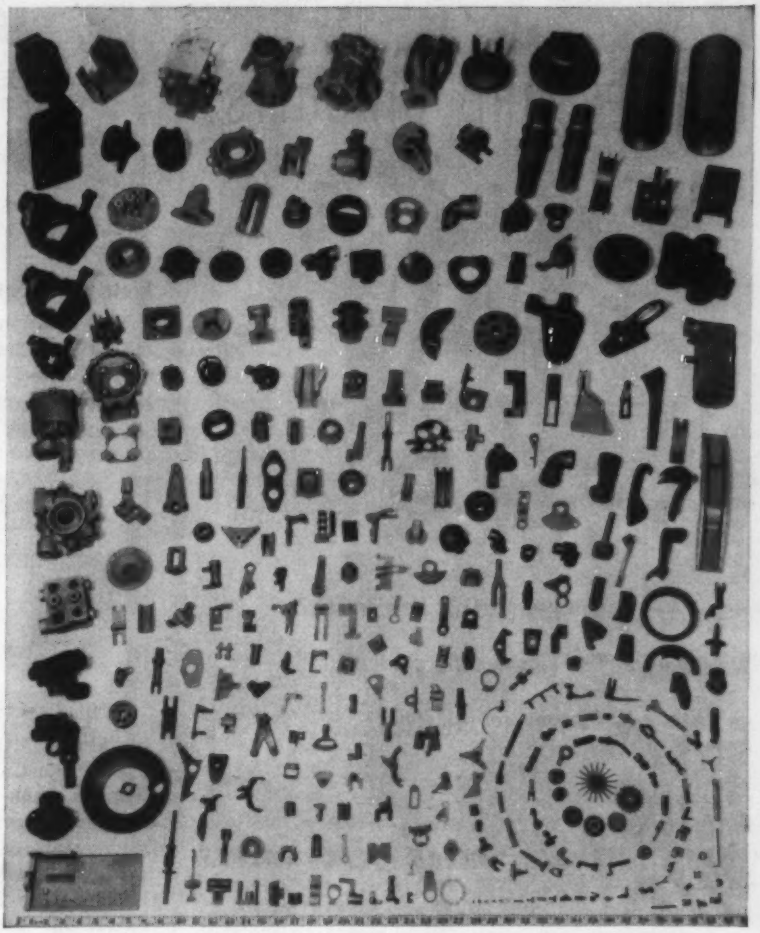
The following Technical Notes are available:

3894. A study of the Impact Behavior of High-Temperature Materials—23 pages.

3923. Effect of Chord Size on Weight and Cooling Characteristics of Air-Cooled Turbine Blades—37 pages.

3925. Preliminary Metallographic Studies of Ball Fatigue Under Rolling-Contact Conditions —38 pages.

3927. Preliminary Investigation of the Effect of Surface Treatment on the Strength of a Titanium-Carbide 30-Percent Nickel Base Cement—16 pages.



Investment castings

¼ ounce to 30 pounds . . . up to 12 inches in length . . . 160 ferrous and nonferrous alloys

Precision Metalsmiths makes them all—a million pieces for your production or a few at a time, as you develop a product. Pictured above are some of the investment castings we're making regularly.

Cast to close tolerances and accurate in details, such parts require surprisingly little finishing. Expensive pre-assembly machining is avoided, since complicated parts are produced as single units. We do the assembling with expendable patterns.

Send for the free book, "Pour Yourself an Assembly", describing this time-saving method. Precision Metalsmiths, Inc., 1083 East 200th Street, Cleveland 17, Ohio.

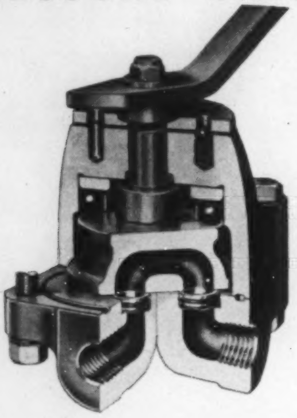
pour yourself an assembly with

PRECISION METALSMITHS, Inc.

Investment Castings

Circle 492 on page 19

DO YOU **CONTROL** YOUR HI-PRESSURE CIRCUITS?



1. Can you shut off flow tightly?

2. Can you throttle gradually?

3. Can you get full flow?

① ***MANUAL "SHEAR-SEAL" VALVES***

(1500, 3000 and 6000 P.S.I.)
are leakproof and stay leakproof for years of service with little or no maintenance; no internal port to port leakage in the detented positions and, of course, no external leakage. Sealing qualities actually improve with use, due to wear compensating lapping action of "Shear-Seals."

② You get excellent throttling, smooth action to any degree of flow without fighting the fluid pressure.

③ Quick as a quarter turn of the handle you can open the full flow (or shut it off) with surge dampening action, because the round tubular passages have no spools or poppets obstructing flow.

BARKSDALE VALVES

5125 Alcoa Avenue, Los Angeles 58, California

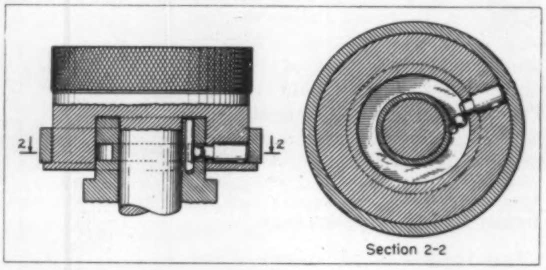
Ask for bulletin 5-H, -A and -W.

NOTEWORTHY

Patents

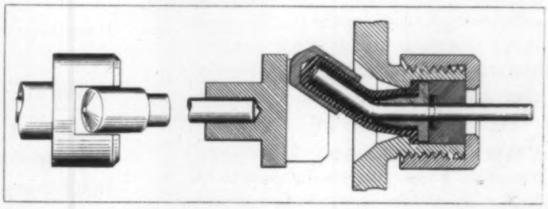
Multiple-Revolution Limit Stop

Free rotation through nearly two revolutions is permitted by a limit-stop mechanism designed for use on control knobs and similar adjusting devices. Circular track on external surface of one rotary element contains a free-rolling ball and a fixed obstruction pin. Projecting into the circular track from the adjustable knob is a second pin. In position shown, further clockwise rotation of the device is blocked by interference of the two pins and the ball. However, after one counterclockwise turn of the knob, the ball is picked up by the moving pin and rolls through nearly one more revolution of the knob before again blocking rotation. *Patent* 2,780,941 *assigned to Kollmorgen Optical Corp. by Ernst O. Kollmorgen.*



Sealed Angle-Shaft Drive

Friction torque is low and fluid sealing is positive in an angle-shaft drive designed to transmit shaft rotational motion through fluid-filled instrument housings. Molded flexible sleeve, supported against collapse by an internal coil spring, encloses the angle shaft and provides the positive-seal feature. Motion can be transmitted in either direction through the drive. *Patent* 2,784,597 *assigned to Badger Meter Mfg. Co. by Jacob C. Miller.*



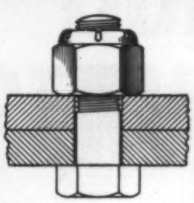
Hydraulic Thrust Bearing

Shaft end thrust is supported by a confined volume of hydraulic fluid in a low-friction thrust bearing. Principal components of the bearing are a closed-end

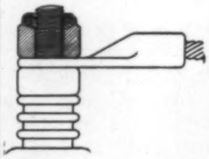
Circle 493 on page 19

Ten fastening problems solved by ELASTIC STOP nuts

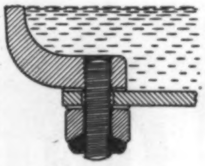
TIGHTENED AGAINST THE WORK



Vibration and impact proof bolted connections in standard applications.

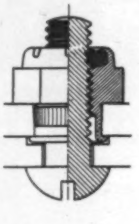


On all electrical terminals subjected to vibration in transit or operation, and for any electrical or electronic assembly where positive contact must be maintained.

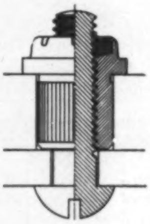


To seal bolt threads where leakage past stud threads must be prevented.

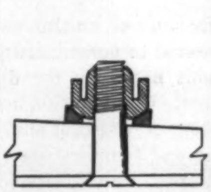
FOR MANY SPECIAL FUNCTIONS



Blind fastening applications where nut is "clinched" into sheet metal . . . becoming self-retaining as well as self-locking.

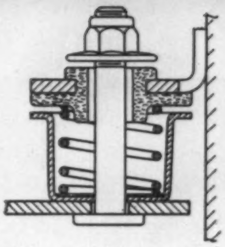


To eliminate drilling and tapping and provide steel thread strength for soft metals, an ESNA spline nut is pressed into a bored hole in casting.

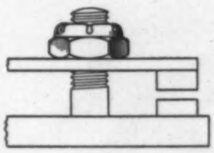


Simplified self-aligning self-locking fastener for bolting two non-parallel surfaces.

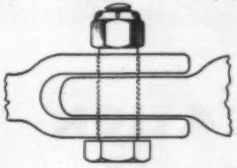
LOCKED ANYWHERE ON THE BOLT



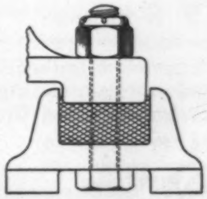
Spring-mounted connections or dynamic balancing, where nut must stay put yet be easily adjusted. (Flanged face eliminates need for extra washers.)



On make and break adjustment studs where accurate contact gaps must be maintained. Note "thin" height design for limited clearance.



For bolted connections requiring predetermined play.



For rubber-insulated and cushion mountings where the nut must not work up or down.

HOW THESE NUTS SOLVE SO MANY FASTENING PROBLEMS, ELIMINATING EXTRA PARTS AND OPERATIONS...

The red locking collar of an ELASTIC STOP® nut grips bolt threads with a perfect fit that will not loosen under severe vibration or stress reversals, and seals against liquid seepage. By bringing nut and bolt metal thread flanks into firm contact it eliminates wear producing axial play. The elastic locking action of the insert-type stop nut does not distort or gall bolt threads. It is reusable many times.

Send for the following free information: Elastic Stop nut bulletin; Rollpin® bulletin. Or enclose a drawing of your product for specific self-locking fastener recommendations. Write to Dept. N30-54.

Circle 494 on page 19

ELASTIC STOP NUT CORPORATION OF AMERICA
2330 VAUXHALL ROAD, UNION, NEW JERSEY

MACHINED BEARING
(1/2 SIZE)
MOLDED SEAL RING
(2/3 SIZE)
VALVE SEAT
(ACTUAL SIZE)
BEARING
(2/3 SIZE)

LUBRICATION A PROBLEM? . . .

why not try *Purebon

* CARBON-GRAPHITE ESPECIALLY DESIGNED FOR MECHANICAL APPLICATIONS

Where lubrication is a problem on bearings, seals, blades and similar sliding or rotating parts, Purebon is often the ideal solution.

PROPERTIES OF PUREBON

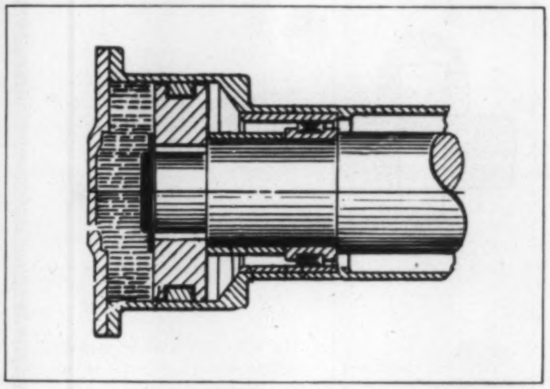
1. Moldable to size.
2. Readily machineable.
3. Chemically inert.
4. Dimensionally stable.
5. Light weight.
6. Low cost where moldable to size.

For complete information about PUREBON write for new Bulletin No. 55, or see Sweet's Product Design File

PUREBON
carbon graphite
for mechanical applications

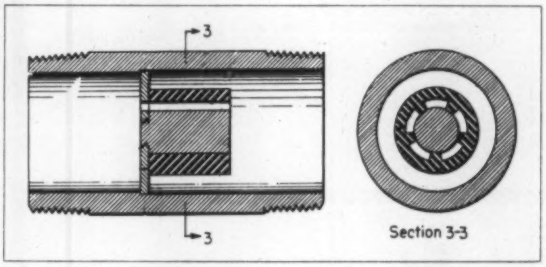
PURE CARBON CO., INC.
442 HALL AVENUE ST. MARYS, PENNSYLVANIA

Noteworthy Patents



cylinder, a piston and a sleeve-type bearing which holds the piston in alignment. Piston ring, which prevents loss of hydraulic fluid from the chamber, is segmented so as to bear centrifugally against the bore wall when the shaft rotates. *Patent* 2,779,638 *assigned to Bauer Bros. Co. by Herman W. Steiniger.*

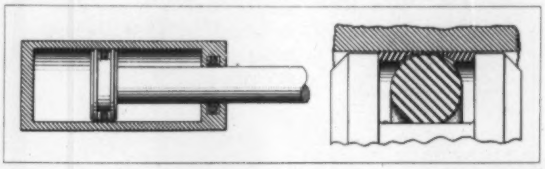
Flow Regulator



Distortion of flexible passages in a flow-control device holds fluid volume flow through the unit substantially constant despite variations in inlet pressure. Unit provides constant flow to automatic washers and similar appliances. *Patent* 2,781,059 *assigned to General Motors Corp. by Edward J. Frey.*

Fluid Seal

Rubbing element of a two-piece hydraulic seal is a thin Teflon ring. Backing pressure necessary for effective sealing by the ring at low fluid pressures is provided by a flexible O-ring. Because of its thin section, the Teflon ring can be stretched to permit installation in the seal groove without necessity for disassembling the supporting member. Combination seal is intended for use on reciprocating or rotating shafts and combines the self-lubricating and temperature resisting characteristics of Teflon with the elastic advantages of rubber. *Patent* 2,784,013 *assigned to Bendix Aviation Corp. by William Groen.*



Circle 495 on page 19

QUICK SERVICE

AN DRILLED FILLISTERS
BOLTS
CAP SCREWS
CAP SOCKETS
DOWEL PINS
COTTER PINS
MACHINE SCREWS
NUTS
PIPE FITTINGS
SET SOCKETS
SHEET METAL SCREWS
STUD BOLTS
TAPER PINS
WASHERS
WOOD SCREWS

ON STAINLESS STEEL FASTENINGS IS STAR'S SPECIALTY

Stainless Stan says "Star's screws have clean, bright and shiny heads"

7,000 sizes and types

RIGHT OFF THE SHELF®

always available . . . you can order **Right from this book in any quantity . . . for immediate delivery!** Write, wire, phone TODAY for your copy of the **New Star Catalog!**

LOOK TO STAR, the one-source resource for quick service on stainless steel fastenings.

STAR STAINLESS SCREW CO.

CORROSION RESISTANT

658 Union Blvd., Paterson 2, N. J.
Telephone: Little Falls 4-2300
Direct New York 'phone: WIsconsin 7-9041

Circle 496 on page 19

Check with LYNAIR FIRST! ON YOUR AIR AND HYDRAULIC CYLINDER REQUIREMENTS

REGARDLESS OF YOUR NEEDS
WE CAN SUPPLY THEM

Check these Advantages

- √ We engineer and manufacture Air and Hydraulic Cylinders for every application
- √ Cylinders meet J. I. C. standards
- √ Airdraulic cylinders for controlling feed in both directions
- √ New design Piston Packing assures minimum of bypass on hydraulic cylinders
- √ Complete range of sizes, 1½" bore through 8" bore, standard. Larger sizes on request.
- √ A full range of Air and Hydraulic Boosters.

Delivery to meet your requirements.

WRITE FOR NEW CATALOG

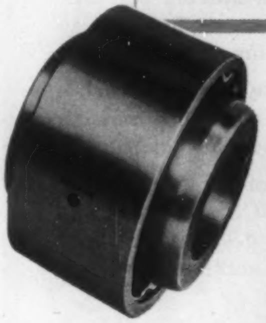
LYNAIR Inc. 3100 E. MICHIGAN AVE.
JACKSON, MICHIGAN

Circle 497 on page 19

RUNS FASTER!

ASSEMBLES EASIER!

COSTS LESS! *than other types of couplings*



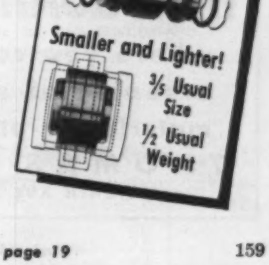
Sier-Bath FLEXIBLE GEAR COUPLINGS

Because Sier-Bath Flexible Gear Couplings are smaller and lighter than conventional flange-and-bolt types they have lower moments of inertia. This means reductions in bending stresses on connected shafts; reductions in overheating and wear of bearings and less resistance to motor drift. Consequently, Sier-Bath couplings deliver greater horsepower capacity, higher rpm. The unique design of Sier-Bath couplings, utilizing chrome vanadium snap rings instead of bolts, means less coupling and uncoupling time . . . so simple a screwdriver is all you need . . . there's never any danger of "freeze-up" even after years of use. Best of all, costs for Sier-Bath couplings average 21% below other leading brands.

Deliveries from stock on most sizes and types.

Special types produced for your specific requirements.

Complete data is in our Catalog C-4, yours for the asking.



Sier-Bath
GEAR and PUMP CO., INC.
9254 Hudson Blvd., North Bergen
Founded 1905 Member A. G. M. A.

Circle 498 on page 19

DAMASCUS - 0140

NEW LEAD HOLDER
will last for years

You need only to get the *feel* of your *new Damascus* Lead Holder to know *"Here is Quality"*

Responds to your lightest touch yet has the sturdiness of *hardened steel.* No plastics or paper-thin brass in this. Take it apart — see the fine quality in the long wearing *DAMASCUS.*

You'd expect to pay $5.00 for such a fine holder — pay only $1.85 *and it's sold with a money back guarantee.*

All stores have not yet heard about the new *DAMASCUS* — write the manufacturer for descriptive folder before you spend another penny for old type holders.

Write today to:
RICHARD BEST PENCIL CO.
SPRINGFIELD, NEW JERSEY
Writing and Drawing Pencils since 1890.

Circle 499 on page 19

AUTOMATIC ENGINE CONTROLS

- **FULL AUTOMATIC CONTROLS**
  For starting, stopping and protection.
- **D.C. SOLENOIDS**
  Continuous or intermittent.
- **RELAYS AND CONTACTORS**
  Power failure relays and engine cranking controls.
- **SPEED SENSITIVE SWITCHES**
  Overspeed and underspeed.
  1, 2 and 3 element.
- **SPECIAL CONTROL PANELS**
  Control systems built to order.
- **SAFETY ALARM SETS**
  Visual and audible alarms for abnormal engine conditions.

SYNCHRO-START PRODUCTS, INC.
Since 1932
8151 N. RIDGEWAY AVE. · SKOKIE, ILL.

Circle 500 on page 19

THOMAS' REGISTER
Q-Z
G-P
A-F
ELCO SCREWS
BERGFELS
BOGUE
ECONOMY FUSES

THOMAS PUBLISHING COMPANY

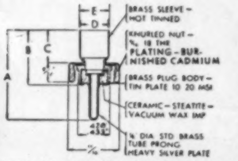
PRODUCT INFORMATION HEADQUARTERS

where you can always find a source of supply for any material or product you need!

THOMAS REGISTER
461 EIGHTH AVE., NEW YORK 1, N. Y.

Circle 501 on page 19

Ideal for
ANTENNA CONNECTIONS
PHOTO-CELL WORK
MICROPHONE CONNECTIONS


E
D
A
B
C
BRASS SLEEVE - HOT TINNED
KNURLED NUT - 18 THR
PLATING - BURNISHED CADMIUM
BRASS PLUG BODY - TIN PLATE 10 20 MSI
CERAMIC - STEATITE - VACUUM WAX IMP
.420 .432
⅛ DIA STD BRASS TUBE PRONG HEAVY SILVER PLATE

SUPPLIED IN 1 & 2 CONTACT TYPES

JONES
SHIELDED TYPE
PLUGS & SOCKETS

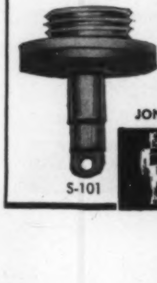
LOW LOSS PLUGS AND SOCKETS FOR HIGH FREQUENCY CONNECTIONS

For quality construction thruout, and fine finish, see diagram above.

101 Series furnished with ¼", .290", 5/16", ⅜", or ½" ferrule for cable entrance. Knurled nut securely fastens unit together. Plugs have ceramic insulation; sockets bakelite. Assembly meets Navy specifications.

202 Series Phosphor bronze knife-switch type socket contacts engage both sides of flat plug contacts—double contact area. Plugs and sockets have molded bakelite insulation.

For full details and engineering data ask for Jones Catalog No. 21



JONES MEANS *PROVEN* QUALITY

Jones
HOWARD B. JONES DIVISION
CINCH MANUFACTURING CORPORATION
CHICAGO 24 ILLINOIS
SUBSIDIARY OF UNITED-CARR FASTENER CORP.

Circle 502 on page 19

Now a wide selection of

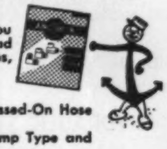
ANCHOR

S.A.E. Straight Thread "O" Ring Boss Adapters

They're new

— and especially designed for use with the new S.A.E. Boss. Anchor S.A.E. Straight Thread, "O" Ring, Boss Type Adapters insure positive, leakproof connections. The positive "O" Ring seal eliminates the need for excessive tightening — therefore removing the danger of thread distortion, and cracking and distorting of valve body seats—common causes for leaks. Proper positioning of hoses is conveniently accomplished, avoiding twisting strains. They may be removed and reinstalled many times without impairing efficiency. Anchor's new S.A.E. Boss Type Adapters are now available in a large range of sizes and in quantities to satisfy your needs. Dimensional diagrams, cross-sectional views and engineering data on these new S.A.E. Adapters are given in the new Anchor Catalog No. 202 — write for your copy.

Andy Anchor says:
Catalog No. 202 also gives you engineering data on the broad line of Anchor Adapter Unions, Adapters and Pipe Fittings.



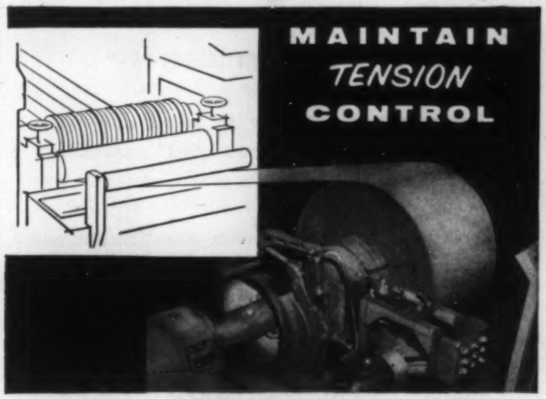
Also ask for

Catalog No. 100 — Anchor Pressed-On Hose Assemblies.
Catalog No. 301 — Anchor Clamp Type and Reusable Couplings.

ANCHOR COUPLING CO. INC.

366 North Fourth Street, Libertyville, Illinois
Branch Offices: Dallas, Tex., Plymouth, Mich.

Circle 503 on page 19



MAINTAIN *TENSION* CONTROL

with Wagner Actuating System and Brakes

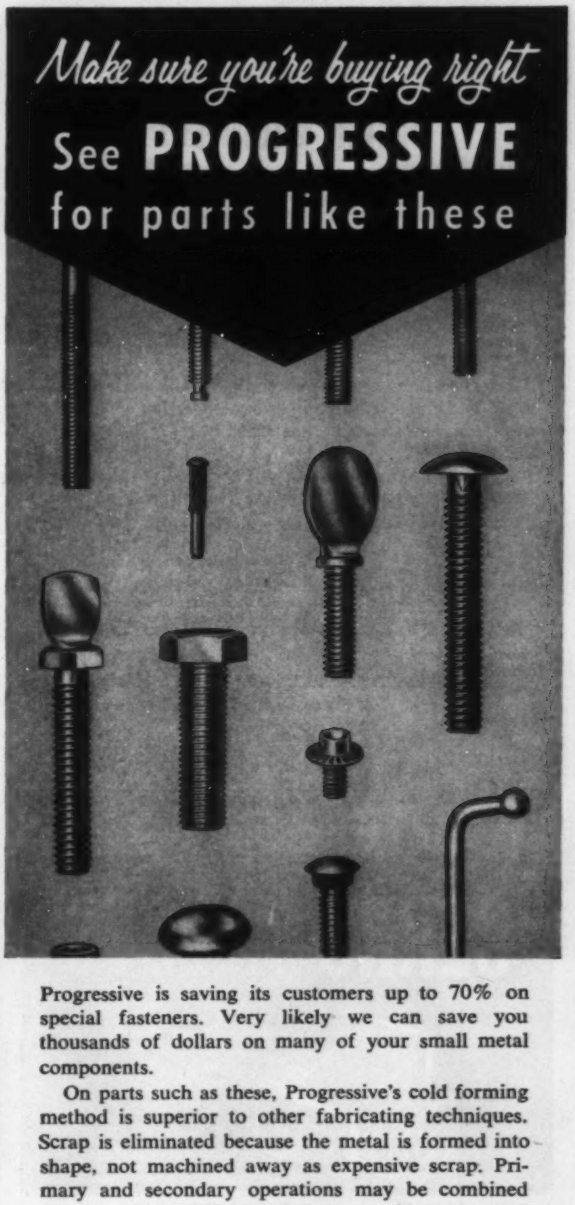
Now, you can keep easily adjustable tension on heavy rolls used in steel slitting operations—in handling paper, and in other similar applications. Wagner Industrial Brakes maintain tension on the rolls and permit emergency machine stops, while Wagner Actuating Systems provide smooth, manually operated control. In the steel slitting machine installation shown above, a regulating valve is used to establish the amount of tension required for various materials and gage thicknesses. A hand operated application valve is used to apply or release the roll tension during set-up and operation.

Your nearby Wagner field engineer will develop detailed specifications to meet your special application. Call him today.

157-5

Wagner Electric Corporation
6404 PLYMOUTH AVE., ST. LOUIS 14, MO.

Circle 504 on page 19



Make sure you're buying right

See **PROGRESSIVE**
for parts like these

Progressive is saving its customers up to 70% on special fasteners. Very likely we can save you thousands of dollars on many of your small metal components.

On parts such as these, Progressive's cold forming method is superior to other fabricating techniques. Scrap is eliminated because the metal is formed into shape, not machined away as expensive scrap. Primary and secondary operations may be combined more readily to effect savings in machine time and between-machine materials handling. Work quality is just as you want it—we won't let it out unless it is.

You may have parts right now that our engineers could value analyze for you. Send us the prints. A Progressive quote is a sure indicator that you are buying right!

**Machine screws and special fasteners are our business . . .
Including square and hexagon machine screw nuts, Sems fasteners, slotted tapping screws and Phillips Head Screws**

STANDARDS AND SPECIALS CUSTOMIZED FOR YOUR NEEDS

THE PROGRESSIVE MFG. CO.
Division of The Torrington Company
52 Norwood Street, Torrington, Connecticut

Circle 505 on page 19

DESIGN ENGINEERS

Challenging positions are available for design engineers to work on interesting projects in the field of high speed mechanisms. We prefer men with B. S. degrees in mechanical engineering and from three to five years' experience in Machine Design.

These positions offer opportunity to use your initiative and creative ability, and association with outstanding personnel in this field.

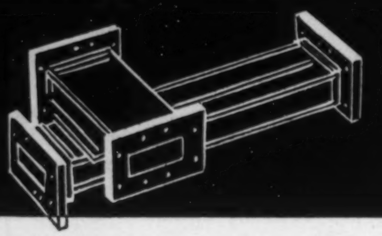
We offer excellent employee benefits and good salaries. For further information please write or send resume to

E. P. Bloch

ARMOUR RESEARCH FOUNDATION
of
Illinois Institute of Technology
10 West 35th Street
Chicago, Illinois

Circle 506 on page 19

CERRO ALLOYS



for electroforming accurate avionics parts

Cerro Alloy mandrels are used in the electroforming of this microwave coupler. The four aluminum flanges and an internal brass iris plate are "grown in place" by electroforming nickel around the flanges, plate and mandrel. The final step is the melting out of the Cerro Alloy mandrel. It is estimated that electroforming reduced the cost of this part by almost 50%, with results in accuracy, finish and uniformity attainable by no other method.

See you at the Design Engineering Show Coliseum, New York, Booth #1222

• Send for further information.

CERRO DE PASCO SALES CORPORATION
300 Park Avenue Room 1508 New York 22, N. Y.

Circle 507 on page 19

3 NEW REPRINTS FROM

MACHINE DESIGN

"DESIGNING ELECTRONIC EQUIPMENT FOR MAINTAINABILITY"

by John D. Folley, Jr. and James W. Altman

Complete reprint of 12-part series. Covers a host of ideas and suggestions as aids in designing electronic equipment for both preventive and corrective maintenance.

$1.00 per copy

●

"HYDRAULIC SERVO FUNDAMENTALS" Vol. I

by J. M. Nightingale

Covers both theoretical and practical aspects of servo system design. Applicable to control systems in general—electrical, hydraulic, pneumatic, or combined systems. Complete reprint of 5-part series.

$1.00 per copy

●

"SPEED REDUCERS AND GEARMOTORS"

by W. S. Miller, Associate Editor, MACHINE DESIGN

Design manual on how to select and apply packaged speed reducers and gearmotors. Covers reducer classification, reducer performance rating, reducer selection factors, reducer installation, gearmotor classification and gearmotor selection factors.

$1.00 per copy

ORDER YOUR COPIES TODAY

MACHINE DESIGN
Reader Service
Penton Building
Cleveland 13, Ohio

☐ Remittance Enclosed.

☐ Please bill me.

Send me____copies of "DESIGNING ELECTRONIC EQUIPMENT FOR MAINTAINABILITY" at $1.00 each

Send me____copies of "HYDRAULIC SERVO FUNDAMENTALS" Vol. I. at $1.00 each

Send me____copies of "SPEED REDUCERS AND GEARMOTORS" at $1.00 each

NAME ________________ TITLE ____________
COMPANY ______________________________
ADDRESS ______________________________
CITY ________________ ZONE_____ STATE______

(Add 3% to orders in Ohio to cover State Sales Tax)

MECHANICAL ENGINEERS

Research and Development

Interesting positions open for mechanical engineers on a wide variety of projects in the following fields:

- Machine Design
- Servomechanisms
- Experimental Stress Analysis
- Vibration and Structural Dynamics

B.S. to Ph.D in mechanical engineering with 3 to 5 years' experience in one of these fields essential. These are permanent positions offering an opportunity to use your initiative and creative ability. We offer excellent employee benefits including tuition free graduate study. For employment application, please write

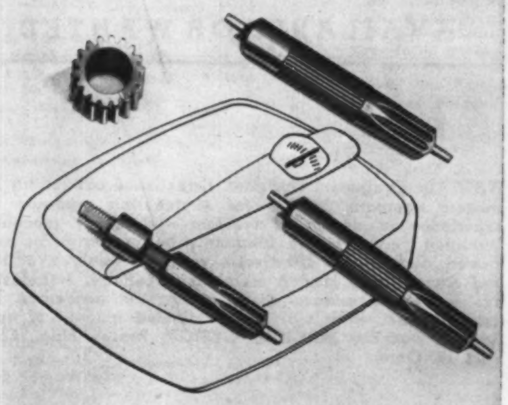
E. P. Bloch

ARMOUR RESEARCH FOUNDATION
of
Illinois Institute of Technology
10 West 35th Street
Chicago, Illinois

Circle 508 on page 19

20 TO 200 D.P.

SEND YOUR PRINTS FOR QUOTATION



SPURS • HELICALS • WORM AND WORM GEARS
STRAIGHT BEVELS • LEAD SCREWS • RATCHETS
CLUSTER GEARS • RACKS • INTERNALS • ODD SHAPES

THE *Finest* IN GEARS

Beaver Gear Works Inc.

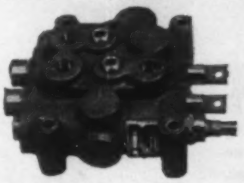
1031 PARMELE ST. ROCKFORD, ILLINOIS

Circle 509 on page 19

HUSCO
HYDRAULIC UNITS

Primarily Engineered for Construction and Materials Handling Equipment, HUSCO Hydraulic Units are preferred for Their Space-Saving, Positive Operational Control and Cost-Saving Efficiency.

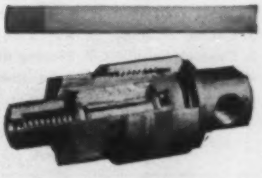
HUSCO HYDRAULIC CONTROL VALVES



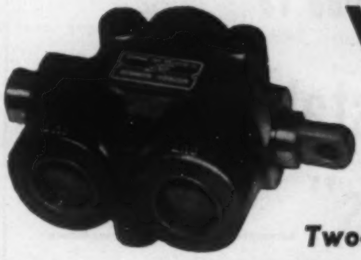
Here is new engineered compactness in multiple-purpose valves that offer many advantages. Available in a full range of sizes with capacities from 6 to 60 G.P.M., in single-acting, double-acting and float position operational control, with from one to four cast-on-bloc plunger arrangements. Designed with fine throttling control in operating positions, they provide built-in adjustable relief valves and built-in check valves in operating circuit, and assure practically unrestricted flow through the valve. Available in either Series or Parallel circuits, with or without High Pressure Carry-over.

HUSCO ROTARY SWIVEL

Low cost, highly efficient Rotary Swivel designed for both high pressure and high operating speeds, particularly in the brake and clutch field. Compact, for use in close quarters. Has spring-loaded Teflon rings, self-centering ball thrust bearing, highly efficient axial bearings. Size, only 3" x 1½".



NEW HUSCO Selector Valves



Provide accurate control of Two-Line Sequence

These new precision-machined selector valves, unusually compact, space-saving, and provide instantaneous adjustment for either of the fluid lines. Important addition to the HUSCO line of hydraulic valves, cylinders, pumps and controls, the new Series 3070 Selector Valves are available in two sizes—for capacities up to 30 and 60 g.p.m.

Write for engineering specifications on the new HUSCO Series 3070 Selector Valves, and suggestions on their profitable adaptation on your equipment.

Check HUSCO first for modern hydraulic units engineered to your needs.

HUSCO ®

HYDRAULIC UNIT
SPECIALTIES CO.
PUMPS • VALVES • CYLINDERS
WAUKESHA, WISCONSIN

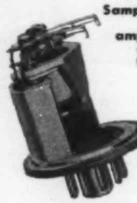
Circle 510 on page 19

VHS* RELAY

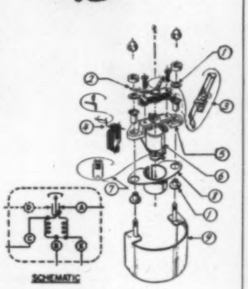
(*Very High Sensitivity)

Model 266

Sample specs. are: 0.2 micro-amperes, (12,000 ohms coil) or, 0.1 millivolts, (5 ohms.)



● The VHS is a balanced armature, Alnico magnet type relay. It is internally shock-mounted and resistant to vibration. The screw-on cover is gasket sealed. It can be opened and resealed. Connections: 9 pin octal style. Dimensions: 1¾ diameter x 2¼ long. Weight: 4 ounces. Sensitivity: Infinite variations from 0.2 Ua. to 10 Amp. or 0.1 Mv. to 500 volts, self contained. Higher volts or amps with external multipliers. A.C. rectifier types. Trip point accuracies to 1%. Differential 1%. The degree of resistance to shock and vibration primarily depends upon sensitivity and type of action wanted. In general, the relays will not be permanently damaged by shocks of 100 G's and vibrations up to 2,000 cps at 3-4 G's. The most sensitive relays may close their contacts under these conditions. Contacts: SPST or SPDT, 5-25 Ma. D.C. Other ratings to ½ Amp. A.C. A locking coil gives high pressure and chatter free contact even under shock and vibration. Prices on the order of $20-$80. Delivery 4 to 6 weeks. Assembly Products, Inc., Chesterland 51, Ohio. West Coast: Box XX, Palm Springs 51, Cal.



1. Shock mount
2. Contact assemby
3. Contact detail
4. Armature with contact detail
5. Cast bracket
6. Alnico magnet
7. Bearing detail
8. Yoke (steel)
9. Mounting frame

Booth 1323, Design Engineering Show, May 20-23, Coliseum, N.Y.C.
Circle 511 on page 19

MACHINE DESIGN
ENGINEERS

who can meet the challenge of keeping our automatic tube production equipment the most modern and efficient in the country.

You'll work and live in delightful upstate New York (Elmira) where lovely homes, fine schools and excellent shopping are minutes apart. Near famous Finger Lakes year 'round vacation land. Fishing, hunting, boating, swimming.

FIND OUT TODAY about the opportunities for you in the design of automatic machines for production of electronic tubes. Experience in the design of special purpose medium weight automatic machinery required. Vacuum tube equipment experience desirable but not essential.

Phone 9-3611 collect, or send resume to Mr. W. Kacala, Dept. M-1A4.

Westinghouse

ELECTRONIC TUBE DIV. **ELMIRA, N. Y.**

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

Design Guide to

"Adjustable-Speed Drives" ____________

- **ELECTRICAL**
- **MECHANICAL**
- **HYDRAULIC**

Here, in one book—148 pages, with 24 tables, 119 charts and 171 illustrations—is what the designer should know about adjustable speed.

$2.00
per copy

MACHINE DESIGN READER SERVICE
Penton Building Cleveland 13, Ohio

ENGINEERS
AVAILABLE OR WANTED

WANTED: Equipment Designer. Established expanding midwestern company looking for engineering graduate with experience in design of medium and heavy machinery. Qualified person would ultimately be in charge of newly formed department. Knowledge of stress analysis of static and dynamically loaded members necessary. Non-destructive testing experience desirable but not necessary. Customer contact work will require limited amount of travel. Address Box 916, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

WANTED: Technical Editor. Automation has an opening for an engineer with manufacturing-production-equipment background and ability to write. Age 25-30.
Headquarters are in Cleveland, but there will be opportunity to travel on editorial assignments and attend meetings, expositions, etc.
This is a real challenge for a man with enthusiasm for writing and a strong creative urge to broaden his perspective and assist industry in effectively applying the techniques of automation.
Please send particulars to the Editor, AUTOMATION, Penton Building, Cleveland 13, Ohio.

Advertising Index

AC, The Electronics Division, General Motors Corporation 167
Aeronautical Division, Robertshaw-Fulton Controls Co. 152
Allen, A. K., Co., The 138
Allen Manufacturing Co. 21
Allis-Chalmers, General Products Division 23
Aluminum Company of America 150
American Brake Shoe Co., Denison Engineering Division 140
American Brass Co., The 4
American Nickeloid Co. 130
American Stock Gear Division, Perfection Gear Co. 136
American Welding & Manufacturing Co., The 149
Anchor Coupling Co., Inc. 161
Armour Research Foundation of Illinois Institute of Technology 162, 163
Armstrong Cork Co., Industrial Division 39
Arrow-Hart & Hegeman Electric Co., The .. 37, 38
Assembly Products, Inc. 164
Associated Spring Corporation 52, 53
Automotive Gear Division, Eaton Manufacturing Co. 16

Bakelite Co., Division of Union Carbide and Carbon Corporation 64, 65
Barksdale Valves 156
Barnes-Gibson-Raymond, Division of Associated Spring Corporation 52, 53
Barnes, John S., Corporation 11
Barnes, Wallace, Co., Division of Associated Spring Corporation 52, 53
Barnes, Wallace, Co., The, Ltd., Division of Associated Spring Corporation 52, 53
Beaver Gear Works, Inc. 163
Best, Richard, Pencil Co. 160
Bethlehem Steel Co. 119
B-G-R Cook Plant, Division of Associated Spring Corporation 52, 53
Bound Brook Oil-less Bearing Co. 9
Bruning, Charles, Co., Inc. 44, 45
Bunting Brass and Bronze Co., The 131

Cannon Electric Co. 125
Carter Controls, Inc. 33
Cash, A. W., Valve Manufacturing Corporation 142
Central Foundry Division, General Motors Corporation 34, 35
Cerro De Pasco Sales Corporation 162
Chain Belt Co. 54
Cinch Manufacturing Corporation, Howard B. Jones Division 160
Cleveland Worm & Gear Co., The .... Inside Back Cover
Crucible Steel Company of America 42
Cuno Engineering Corporation 148
Cutler-Hammer, Inc. .... Back Cover

Damascus Tube Co. 70
De Laval Steam Turbine Co. 60
Denison Engineering Division, American Brake Shoe Co. 140
Dow Corning Corporation 55, 56
Duff-Norton Co. 30
Dunbar Brothers Co., Division of Associated Spring Corporation 52, 53
du Pont, E. I., de Nemours & Co., Inc. 69
Durakool, Inc. 152

Eaton Manufacturing Co., Automotive Gear Division 16
Elastic Stop Nut Corporation of America 157
Electro Metallurgical Co., A Division of Union Carbide and Carbon Corporation .. 51

Fawick Corporation, Fawick Airflex Division .. 41
Federal-Mogul-Bower Bearings, Inc., National Seal Division 129
Fenwal, Inc. 133

Galland-Henning Nopak Division 40
General American Transportation Corporation, Parker-Kalon Division 67
General Electric Co. 151
General Motors Corporation, Central Foundry Division 34, 35
Gibson, William D., Co., The, Division of Associated Spring Corporation 52, 53
Gilman, Russell T., Inc. 138
Goodrich, B. F., Co., The, Aviation Products Division 43
Goodrich Chemical, B. F., Co., A Division of The B. F. Goodrich Co. 117
Goodyear Tire & Rubber Co., Industrial Products Division 2

Hampden Brass and Aluminum Co. 134
Howell Electric Motors Co. 121
Hydraulic Unit Specialties Co. 163

Industrial Tectonics, Inc. 134

Jones, Howard B., Division, Cinch Manufacturing Corporation 160

Koppers Co., Inc., Chemical Division 61

Laclede Steel Co. 141
Linear, Inc. 66
Link-Belt Co. 72
Lukens Steel Co. 115
Lynair Inc. 159

Manross, F. N., & Sons Co., Division of Associated Spring Corporation 52, 53
Mechanics Universal Joint Division, Borg-Warner Corporation 57
Metals & Controls Corporation, Spencer Thermostat Division 135
Micro Switch Division, Minneapolis-Honeywell Regulator Co. 58, 59
Midland Steel Products Co., The 154
Milwaukee Division of Associated Spring Corporation 52, 53
Minneapolis-Honeywell Regulator Co., Micro Switch Division 58, 59
Mueller Brass Co. 48, 49

National Seal Division, Federal-Mogul-Bower Bearings, Inc. 129
National Supply Co., The, Industrial Products Division 166
New Hampshire Ball Bearings, Inc. 147
Norgren, C. A., Co. 24

Ohio Division of Associated Spring Corporation 52, 53
Oilgear Co., The 7

Parker-Kalon Division, General American Transportation Corporation 67
Peerless Electric Co., The, Electric Motor Division 153
Penn Engineering & Manufacturing Corporation 136
Perfection Gear Co., American Stock Gear Division 136
Polymer Corporation of Pennsylvania, The .. 26
Post, Frederick, Co. 15
Precision Metalsmiths, Inc. 155

MACHINE DESIGN

Penton Building, Cleveland 13, Ohio
Main 1-8260

BUSINESS STAFF

ROBERT L. HARTFORD
Business Manager

Mary L. Callahan
Advertising Service Manager

Richard A. Templeton
Research and Circulation Manager

David C. Kiefer
Marketing Director

Robert E. Lessing
Production Manager

District Offices

New York 17 ....60 East 42nd St.
Russell H. Smith, James A. Stangarone
Chandler C. Henley
Murray Hill 2-2581

Simsbury, Conn. ....17 Deerfield Lane
Alan C. Bugbee
Oldfield 8-4764

Cleveland 13 ....Penton Bldg.
Jack W. Walton
Don J. Billings
Main 1-8260

Detroit 35 ....15800 West McNichols Rd.
Charles F. Reiner
Broadway 3-8150

Chicago 11 ....520 North Michigan Ave.
Howard H. Dreyer, Robert Z. Chew
Donald A. Ivins
Whitehall 4-1234

Los Angeles 36 ......5943 West Colgate Ave.
F. J. Fuller
Webster 1-6865

San Francisco 4 ....57 Post St.
Robert W. Walker Co.
Sutter 1-5568

Griffin, Ga. ....1106 Pine Valley Road
Fred J. Allen
Griffin 7854

London, S.W.1 ......2 Caxton St., Westminster

Published by

THE PENTON PUBLISHING COMPANY

G. O. HAYS ....President
R. C. JAENKE ......Executive Vice President
F. G. STEINEBACH ...Vice President and Secy.
F. O. RICE ....Vice President
J. P. LIPKA .Treasurer and Assistant Secretary

Also Publisher of

STEEL, FOUNDRY, NEW EQUIPMENT DIGEST, AUTOMATION

Machine Design is sent at no cost to management, design and engineering personnel whose work involves design engineering of machines, appliances, electrical and mechanical equipment, in U. S. and Canadian companies employing 20 or more people. Copies are sent on the basis of one for each group of four or five readers. Consulting and industrial engineering firms, research institutions and U. S. government installations, performing design engineering of products are also eligible.

Subscription in United States, possessions and Canada for home-addressed copies and copies not qualified under above rules: One year, $10. Single copies $1.00. Other countries: One year, $25. Published every other Thursday and copyright 1957 by Penton Publishing Co., Penton Bldg., Cleveland 13, Ohio. Accepted as Controlled Circulation publication at Cleveland, Ohio.

BPA NBP

The shock of bucket digging into dirt never reaches the engine, because the National Torque Converter absorbs vibration and shock. Converter sizes: 100 to 1000 hp.

When will Torque Converters be standard equipment on big machinery?

It's already started. Look at the picture and you'll see why. A brief instant ago that power-shovel bucket was carrying zero load. Then it rammed into the bank. A second later the load shot up to several tons. Yet the engine is in no danger of stalling. It won't even labor. In that second, the National Torque Converter automatically adjusted the speed of the bucket—down—and its power—up. The engine hardly felt it.

A National Torque Converter saves a little time on every work-cycle of the machine, because it lets the machine work at its top capacity for the entire cycle. Over the day it's a lot of time and a lot of work. If you operate heavy-duty machinery from 100 to 1000 horsepower, it can make a lot of difference in your profits too.

How big a difference? Put our 20 years of experience with high-power fluid transmissions to work finding out for you. Our engineers will investigate your power-transmission problems and give you the answers. Write: The National Supply Company, Two Gateway Center, Pittsburgh 22, Pennsylvania.

THE NATIONAL SUPPLY COMPANY
INDUSTRIAL PRODUCTS DIVISION
Two Gateway Center, Pittsburgh 22, Pa.

Pace-setters in the progress of industrial power transmission

Circle 512 on page 19

Advertising Index

Progressive Manufacturing Co., The, Division of The Torrington Co. 161
Pure Carbon Co., Inc. 158

Raybestos-Manhatten, Inc., Plastic Products Division 127
Raymond Manufacturing Co., Division of Associated Spring Corporation 52, 53
Robertshaw-Fulton Controls Co., Aeronautical Division 152
Rockford Clutch Division, Borg-Warner Corporation 144
Roper, Geo. D., Corporation 132
Ross Operating Valve Co. 1

Safety Socket Screw Co. 31
Seaboard Coil Spring Division of Associated Spring Corporation 52, 53
Sealmaster Bearings, A Division of Stephens-Adamson Manufacturing Co. 36
Sier-Bath Gear and Pump Co., Inc., Coupling Division 159
Sier-Bath Gear and Pump Co., Inc., Gear Division 28
SKF Industries, Inc. 47
Sparta Foundry Co. 50
Spencer Thermostat Division, Metals & Controls Corporation 135
Star Stainless Screw Co. 159
Statham Laboratories 25
Stephens-Adamson Manufacturing Co., Sealmaster Bearings Division 36
Stow Manufacturing Co. 146
Superior Tube Co. 68
Sylvania Electric Products Inc., Parts Division 71
Synchro-Start Products, Inc. 160

Thomas Register 160
Thomson Industries, Inc. 123
Timken Roller Bearing Co., The, Steel and Tube Division 29
Tinnerman Products, Inc. 139
Titeflex, Inc. 63
Tomkins-Johnson Co., The 145
Torrington Co., The 13
Torrington Co., The, The Progressive Manufacturing Co. Division 161
Townsend Co. 27
Trent Tube Co. 137

Union Carbide and Carbon Corporation, Bakelite Co. 64, 65
Union Carbide and Carbon Corporation, Electro Metallurgical Co. Division 51

Veeder-Root, Inc. 143
Viking Pump Co. 150

Wagner Electric Corporation 161
Westinghouse Electric Corporation 46, 137-A
Westinghouse, Electronic Tube Division 164
Wheelock, Lovejoy & Co., Inc. 32
White, S. S., Industrial Division .... Inside Front Cover
Willys Motors, Inc. 62

Engineers Available or Wanted 164

MECHANICAL ENGINEERS

DESIGN

DEVELOPMENT

PRODUCTION

Ever wanted to be a member of a real championship team?? As a member of the Product Development Engineering Department your "team play" will include:

DESIGN You create basic design concepts based on practical means of accomplishment. Your concepts are translated by layout draftsmen to a more communicable form under your guidance. In other words, HOW, WHAT, WHY, WHERE systemized.

DEVELOPMENT You evaluate, refine and improve; using the finest PRODUCT IMPROVEMENT TOOLS. These "TOOLS" include the best TEST and RESEARCH facilities available and you have the added advantage of working alongside the top men in this field.

PRODUCTION You supervise the evolution of a production model based upon engineering prototypes resulting from the Design and Development. Produceability and a high degree of reliability will be your responsibility. Your job will include the maintainability and function of Electro-Mechanical Devices, Precision Gear Trains and Packaged Electronics in the fields of Inertial Guidance, Avionics and Jet Engine Fuel Controls.

Job assignments are accomplished by men operating as a team. Our program is expanding and Challenging Opportunities await qualified men for important positions on our Engineering teams. Why not you??
As a part of our Major, Permanent, Company Expansion Program, new plant facilities are being added in suburban Milwaukee.

RECENT ME GRADUATE INQUIRIES ALSO INVITED

Milwaukee offers ideal family living in a progressive, neighborly community combining cultural and shopping advantages with small town hospitality. You and your family will love Milwaukee.
To arrange personal, confidential interview in your locality send résumé today to

Mr. Cecil E. Sundeen
Supervisor of Technical Employment

AC

the ELECTRONICS DIVISION

GENERAL MOTORS CORP.

FLINT 2, MICHIGAN • MILWAUKEE 2, WISCONSIN

REPRINTS AVAILABLE FROM MACHINE DESIGN

Multiple-Circuit Switches

lever – rotary – push or pull

A design manual on the factors to be considered in the selection and application of multiple-circuit switches.

Part One—discusses physical and electrical characteristics of lever-operated switches

Part Two—discusses physical and electrical characteristics of rotary switches

Part Three—discusses physical and electrical characteristics of push or pull switches

Part Four—discusses factors to be considered when selecting switches from these types for a specific application

---

How to select and apply

Electrical Connectors

Separable electrical connectors can often help satisfy several design objectives—convenience, portability or mobility, flexibility. Connectors provide these features in two kinds of circuits—power and signal.

Part One—discusses how to select and apply Electrical Connectors for power circuits

Part Two—discusses how to select and apply Electrical Connectors for signal circuits

Order your
copies today

(Add 3% to orders for delivery in Ohio to cover state sales tax)

MACHINE DESIGN
READER SERVICE

Penton Building
Cleveland 13, Ohio

☐ Remittance enclosed

☐ Please bill me

SEND ME _____ copies of "MULTIPLE CIRCUIT SWITCHES" at $1.00 per copy

_____ copies of "ELECTRICAL CONNECTORS" at $1.00 per copy

NAME ____________________

TITLE ____________________

COMPANY ____________________

ADDRESS ____________________

CITY __________ ZONE _____ STATE ________

Memo to a Show-bound Engineer

SEE THESE ITEMS IN CLEVELAND-FARVAL BOOTHS 222-224
AT THE DESIGN ENGINEERING SHOW IN NEW YORK'S COLISEUM

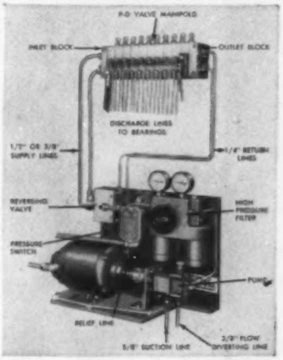
LUBRIVAL a revolutionary new system to supply and circulate oil

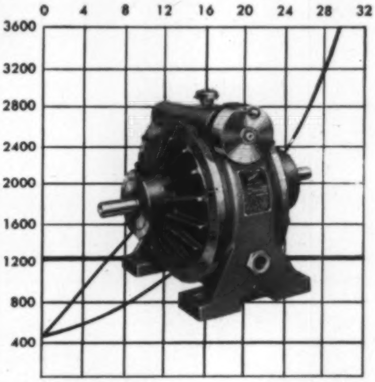
Lubrival is specifically designed for low volume, high pressure circulating lubrication of presses, automatic and semi-automatic machine tools and other machines designed for circulating oil systems.

Lubrival is a Farval system, employing the Dualine principle of delivering oil to measuring valves which pass it under pressure to bearings. Lubricant is forced by positive piston displacement. Flow can be regulated over a range of 10 ounces to 1 gallon per minute.

Lubrival Progressive Dualine Valves, manifolded in any number required, have individual sight indicators. A pressure-sensing mechanism warns of clogged or broken lines in *any part* of the system—a feature entirely new to circulating oil systems.

The Farval exhibit at the Design Engineering Show includes a complete Lubrival system in operation, to demonstrate all features of this new method of supplying and circulating oil.





CLEVELAND SPEED VARIATOR

"The drive that's on the ball"

This unique variable speed drive gives you infinitely variable, stepless speeds up to 9:1 (from ⅓ to 3 times input speed). Precise adjustment gives instant, smooth change of output speed by either a hand wheel on the Variator or by manual or automatic remote control. Simple construction, compact, quiet running.

Power is transmitted from input shaft to output shaft through alloy steel driving balls which are in pressure contact with discs attached to the two shafts. No belts, no slippage, no complicated linkage.

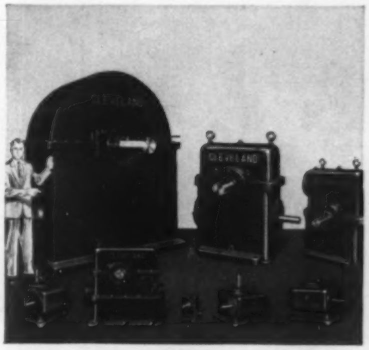
Thousands of units now in use on cigarette-making machines, textile machinery, metalworking machinery, pharmaceutical and chemical processing equipment, transfer tables, conveyors and experimental and testing equipment of many types. See production unit and cutaway model in operation in our exhibit.

WORM GEAR SPEED REDUCERS

Sized for every need

For the many advantages of a compact, right-angle drive, you use a worm gear speed reducer—and when you want top quality, complete dependability and long life, you choose a Cleveland. Cleveland manufactures a broad range of varied types and sizes of worm gear drives—speed reducer units and worm-gear sets to be built into driven machines. Most requirements can be met economically with standard units, either "as is" or with adaptations. We also develop special designs for drive units to meet special needs.

You'll see standard models of Cleveland Worm Gear Speed Reducers in smaller sizes at the Show. Our representatives in attendance will be glad to discuss your power transmission problems. Or write us in detail.



FARVAL

And if you're a stay-at-home—

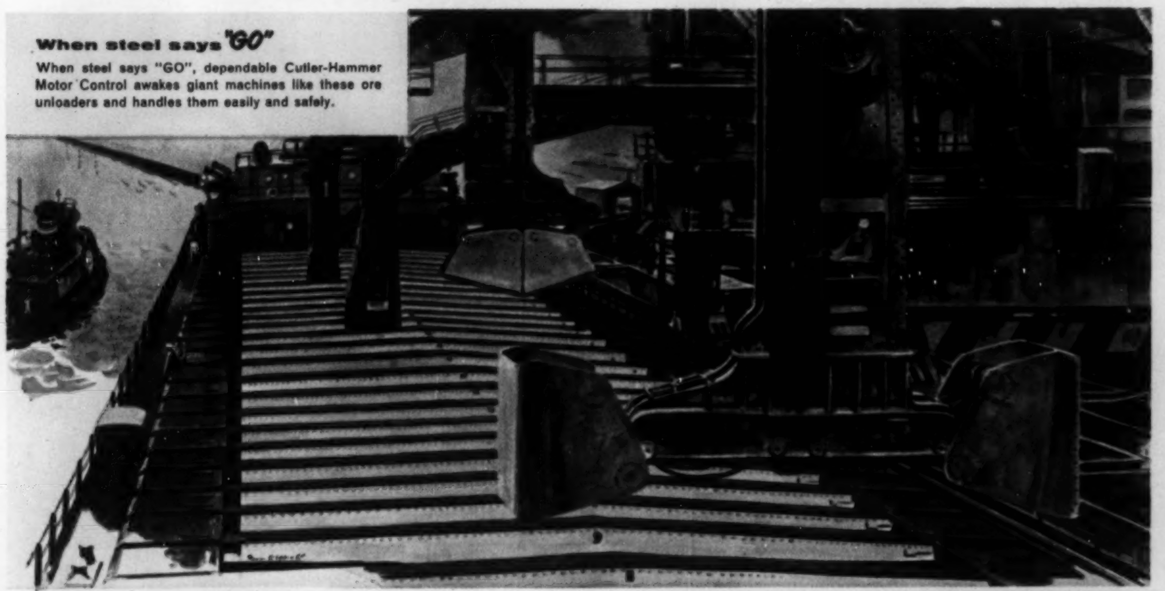
Write for Bulletin 70 which illustrates and describes the new Lubrival circulating oil system, Bulletin K-200 on Cleveland Speed Variators, and/or new Bulletin 145 which shows the complete line of Cleveland Worm Gear Speed Reducers.

THE CLEVELAND WORM & GEAR CO.
3287 East 80th Street • Cleveland 4, Ohio

CLEVELAND
Speed Reducers

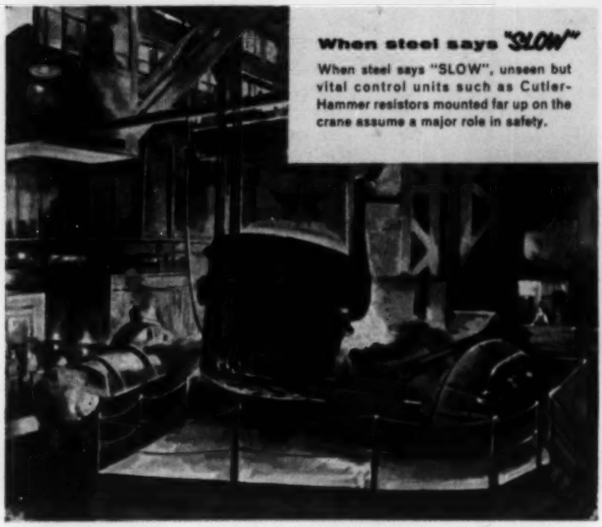
Circle 402 on page 19

Steel sets a stiff pace



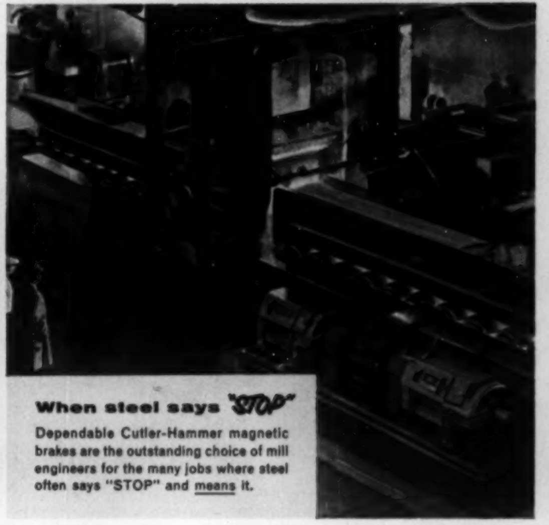
When steel says "GO"

When steel says "GO", dependable Cutler-Hammer Motor Control awakes giant machines like these ore unloaders and handles them easily and safely.



When steel says "SLOW"

When steel says "SLOW", unseen but vital control units such as Cutler-Hammer resistors mounted far up on the crane assume a major role in safety.



When steel says "STOP"

Dependable Cutler-Hammer magnetic brakes are the outstanding choice of mill engineers for the many jobs where steel often says "STOP" and means it.

By its very nature, steel-making cannot tolerate delays. But it is also true that steel-making is tough on equipment, punishes it as few other jobs do. Tie these two facts together and it is easy to see that steel sets a stiff pace at any time. Tie them together under today's maximum mill schedules and you have the toughest trials mill equipment has ever been asked to survive.

This situation puts much meaning into the fact that more steel mills are now buying more Cutler-Hammer Motor Control than ever before in history. Today's operations not only require the utmost dependability in motor control but provide the conditions which most clearly reveal it.

When you require motor control, always remember Cutler-Hammer dependability is extra value at no extra cost. Insist on Cutler-Hammer; experienced engineers everywhere do. CUTLER-HAMMER, Inc., 1310 St. Paul Avenue, Milwaukee 1, Wisconsin. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto.

Cutler-Hammer Three-Star Motor Control sets three new cost-cutting standards; installs easier, works better and lasts longer. Featured by leading machinery builders. Stocked for your convenience by your Cutler-Hammer Distributor.

CUTLER-HAMMER
MOTOR CONTROL
C·H

Circle 403 on page 19